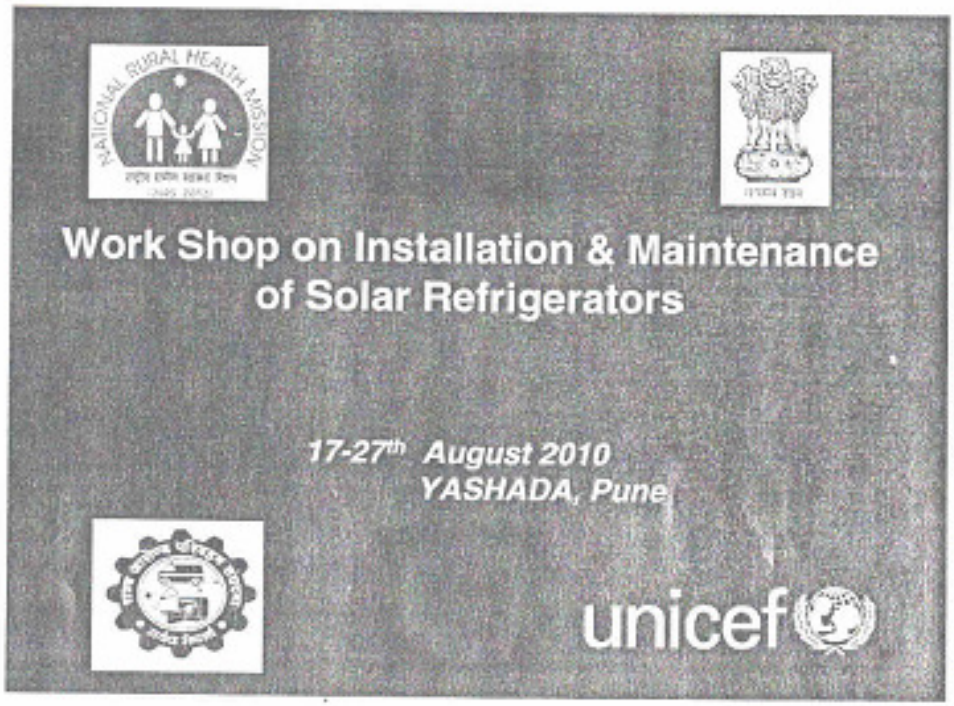


SYSTEM HANDBOOK
DULAS SOLAR POWERED

VC150
REFRIGERATOR/FREEZER

CONTENTS:

Page

SECTION I

SECTION II

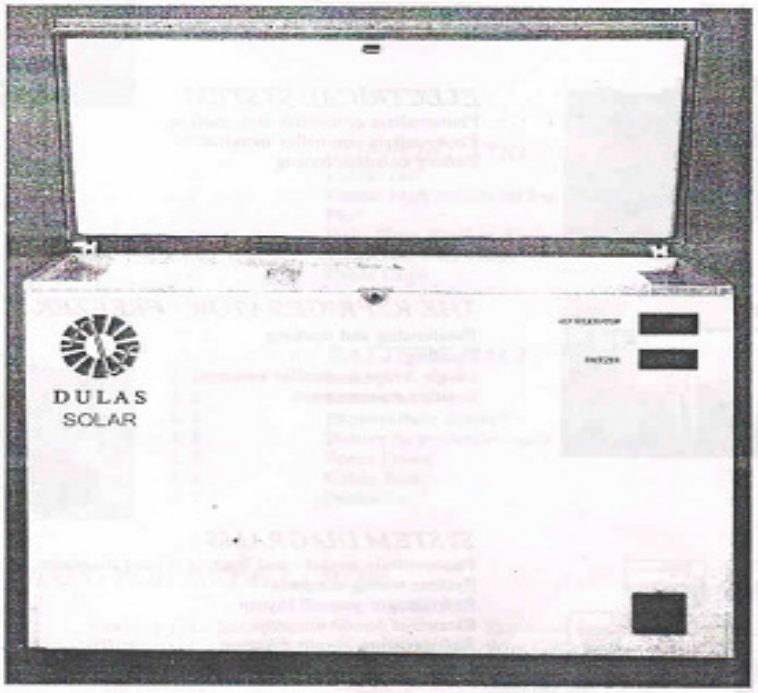
SECTION III

SECTION I

Model - No - 1

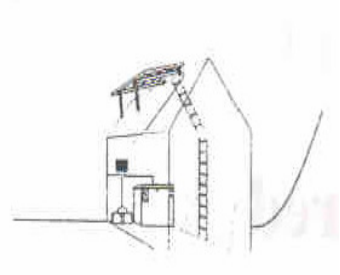
dulas solar international

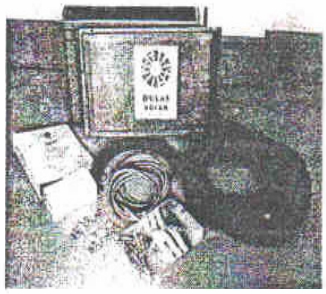
DULAS Solar Powered
VC150 Refrigerator/Freezer
Installation & Operation Manual

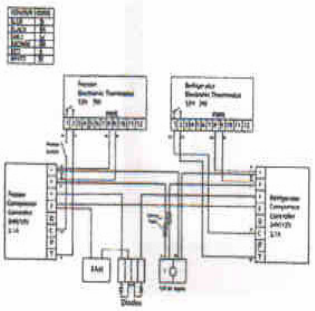


CONTENTS

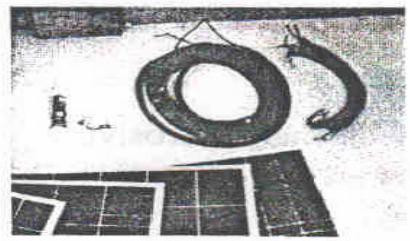
SECTION Page No.



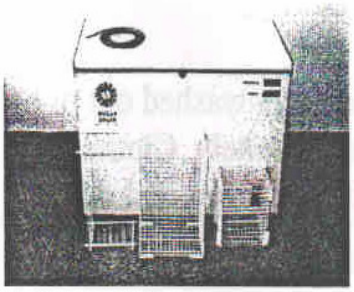




COMPONENTS-CHECK LIST

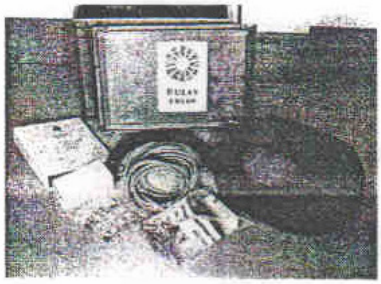


REF	PRODUCT	QUANTITY
	SOLAR ARRAY	
a.1	KD135 solar modules	2
a.2	10m array output cable	1
a.3	0.5m module Interconnect cable assembly	1
a.4	Bolt, plain washer, Nylon washer, Penny washer & Nut	Pack
a.5	Silicon Sealant	1



	REFRIGERATOR	
b.1	DULAS VC150 refrigerator/ Freezer	1
b.2	Refrigerator cable	1

	SUPPORT STRUCTURE	
c.1	Unirac rail	
c.2	Unirac high profile tilt leg kit	2
c.3	Feet	4
c.4	Bolt, plain washer, spring washer & nut	Pack
c.5	Screws & wall plugs	Pack
c.6	Cable clips	



	BATTERY PACK	
d.1	Battery	1
d.2	Battery box	1
d.3	Photovoltaic controller	1
d.4	Battery to controller cable	1
d.5	Spare fuses	3
d.6	Cable ties	Pack
d.7	Padlocks	2

TOOLS REQUIRED FOR INSTALLATION

Pozidriv No.2 Screwdriver
Pliers
Wire Strippers
Drill and Bits
Adjustable Spanner
Slot-head Screwdriver
Wire Cutters
Craft Knife
Hammer & Punch
Size10, 11, 13, 14 & 17mm Spanners

BATTERY SAFETY

Observe operating instructions and position them within sight of battery! Work only on batteries under instruction of skilled personnel!

The electrolyte (diluted sulphuric acid) is extremely corrosive. When working on batteries wear safety glasses and protective clothing.

Acid splashes in the eyes or on the skin must be washed out or off with plenty of water. Then see a doctor immediately. Clothing exposed to acid should be washed out with water without delay.

Electrical danger! In the case of short circuit, extremely high currents can occur which can cause severe burn.

Block batteries or cells are heavy! Ensure secure installation! Only use suitable transport equipment!

Explosion and fire hazard due to explosive gases escaping from the battery. Caution! Metal parts of battery are always live; therefore do not place items or tools on the battery! Avoid short circuits!

No Smoking! Do not expose the battery to an open flame; a glowing fire or sparks as explosion and fire hazards exists.

KNOW YOUR SYSTEM

PREPARATION

Before connecting, some time should be dedicated to working out all the aspects concerned in the system installation.

By following these simple instructions and spending a little time on each, the whole installation process should be easier.

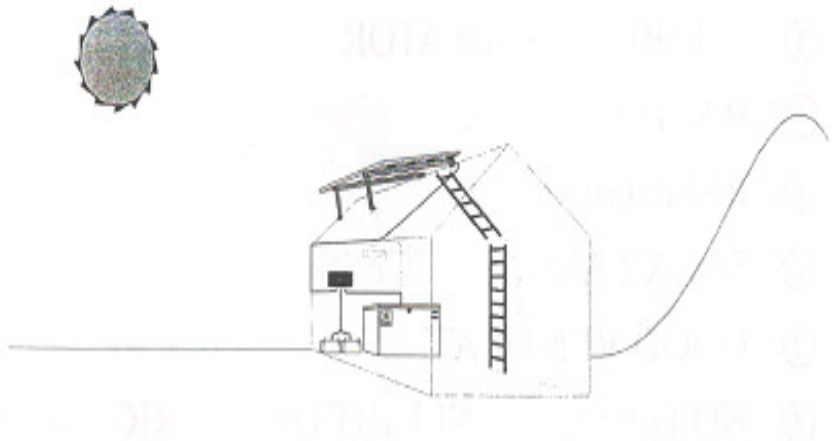
1) Check that all components are present, familiarize yourself with them and make sure that everything has been identified.

2) Discuss and decide a position for refrigerator, ensuring that it is well ventilated, dry and not in direct sunlight. The colder the room, the better the performance.

3) Work out a position for the solar array ensuring that it faces the correct direction, is at the correct tilt angle (see page on support structure orientation), no shading will occur, it will not be damaged and it is accessible for cleaning and maintenance.
4) Work out the route for the solar array output cable, ensuring that there is sufficient length to reach the charge regulator.

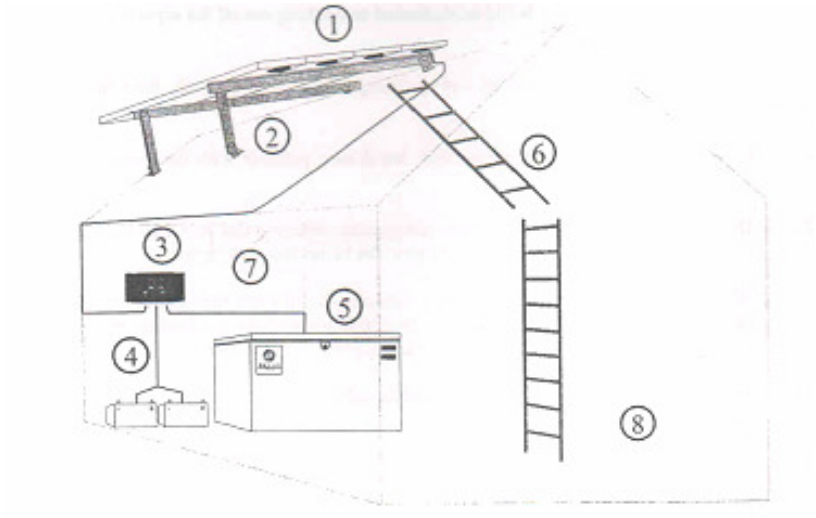
5) Choose a position for the batteries that is well ventilated, dry, safe, not in direct sunlight and accessible for topping up with distilled water. The colder the room the better the performance.

The system when completely installed should look similar to the drawing below. Each component should have a sensible, well thought out, safe location, allowing access for routine maintenance.



KNOW YOUR SYSTEM

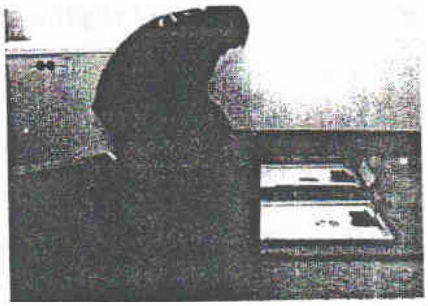
COMPLETED



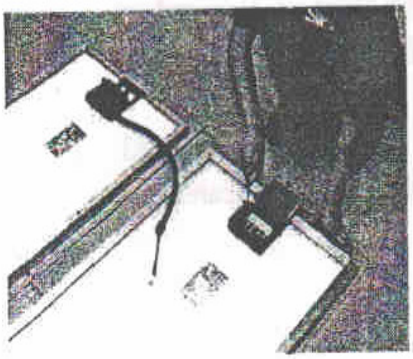
1. SOLAR MODULE ARRAY
2. SUPPORT STRUCTURE
3. CHARGE REGULATOR
4. BATTERY PACK
5. REFRIGERATOR
6. SOLAR ARRAY ACCESS
7. GOOD VENTILATION
8. NO DIRECT SUNLIGHT ON REFRIGERATOR

SOLAR ARRAY
KYOCERA MODULE ASSEMBLY

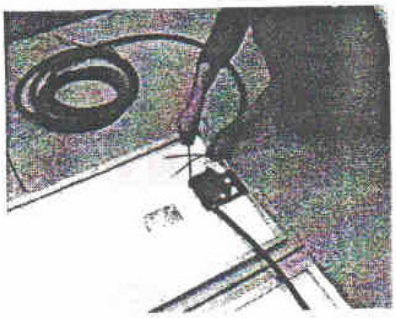
PLEASE READ ALL INSTRUCTIONS THOROUGHLY BEFORE COMMENCING
(FOR 12V WIRING LAYOUTS SEE 'JUNCTION BOX WIRING DIAGRAMS')



After insuring that all the components are present, remove the solar (module a.1) from their cardboard boxes and lay them next to each other on top of the cardboard, with glass facing down. Do not step on the glass module. BROKEN MODULE CANNOT BE USED. Arrange the solar modules so that the junction boxes are all on the same side.



Interconnected the modules with the cables provided (a.3). The interconnected cable has a crimped ring terminal at each end which are easily connected to the Kyocera junction boxes as illustrated below in figure1, (remove plastic unit, screw gland in place, replace plastic nut and connect cable.)



The array output cable (a.2) must then be connected to the nearest module (see system wiring diagram), brown or red wire to +, blue or black wire to -. Ensure that there is sufficient cable to meet the necessary distance then insert into the junction boxes as performed previously.
Note: Due to New cable color regulations brown or red can be used for + ve and blue or black for – ve until 1/4/06 after which time only brown and blue will be permissible.

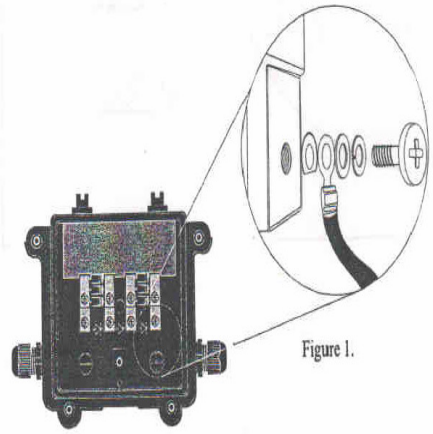


Figure 1.

Lift the cover of the junction box by removing the four screws. Place the ring terminal into position and tighten up the terminal screw until it is gripped securely. Replace the cover of the junction box with the screw provided ensuring a moisture proof seal.

SUPPORT STRUCTURE

ORIENTATION

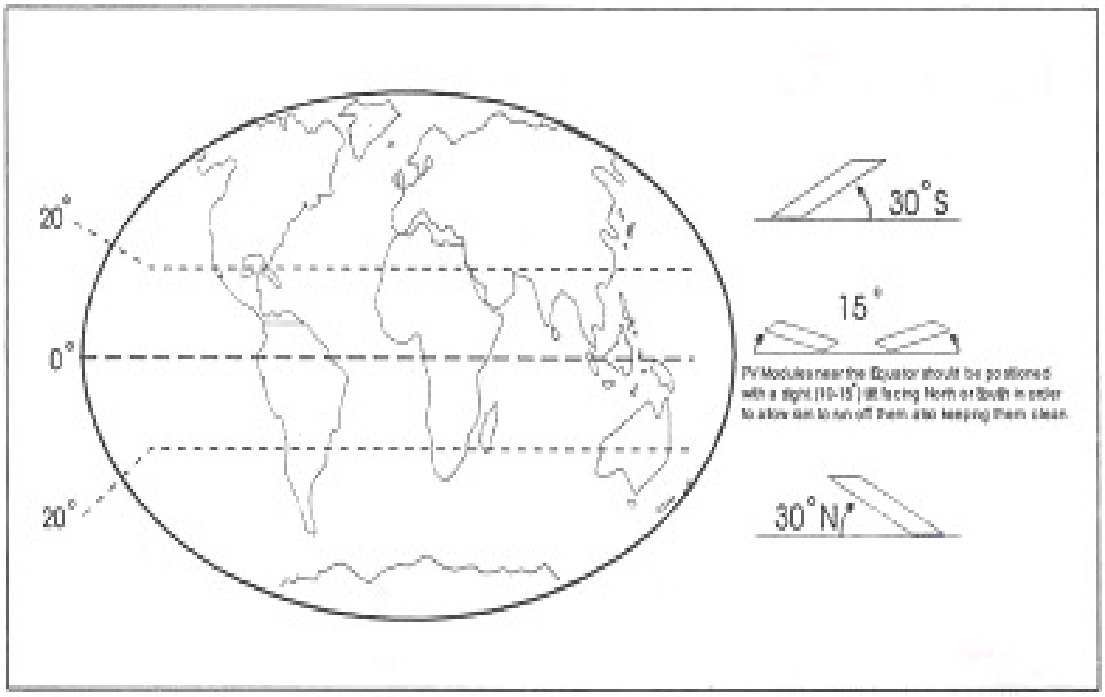
The solar array must be permanently positioned where the module will receive the maximum amount of sunshine, however they are very fragile and should not be located where they may be damaged. A suitable position must be found away from trees and tall objects, to avoid shading the array, as this will impair the performance of the module.

Please ensure that the support structure is:
SECURE AND NOT TWISTED
ACCESSIBLE FOR CLEANING
WELL VENTILATED
SAFE FROM SEVERE WEATHER CONDITIONS
NOT SHADED (BETWEEN 7am & 5 pm)

The solar array should face towards the equator- i.e.
South in the Northern Hemisphere,
North in the southern Hemisphere.

The tilt angle of a solar array is dependent on the country in which it is located. Figure 3 demonstrates common tilt angles. The front of the solar modules must be cleaned every week or when necessary in dusty Ares.

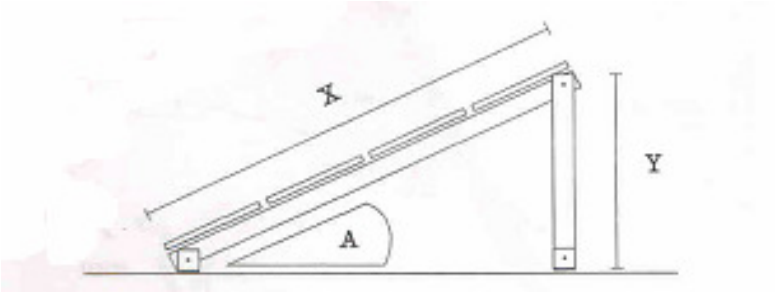
Figure 3.



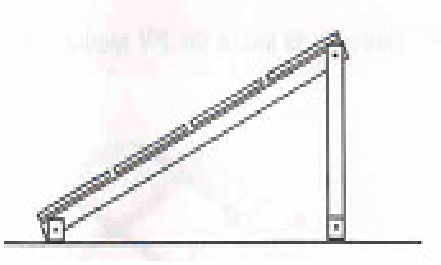
SUPPORT STRUCTURE
ORIENTATION CONTINUED

The support structure is made from pre-drilled galvanized steel angle. If you mounting area cannot be level e.g. you have a sloping roof, then adjusting the foot mounting holes must make the correct angle.

Use the ratios below to calculate your appropriate angle and follow the diagram to position the structure accurately.



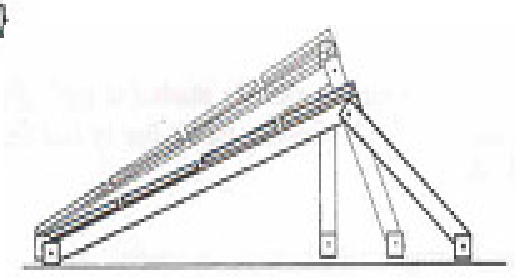
Required angle (A)	Approx. ratio (x:y)		Required Angle (A)	Approx. ratio(x: y)
10^0	6:1		30^0	2:1
15^0	4:1		35^0	1.75:1
20^0	3:1		40^0	1.5:1
25^0	2.4:1		45^0	1.4:1



Changing the position or length of the Tilt legs can alter module angles.

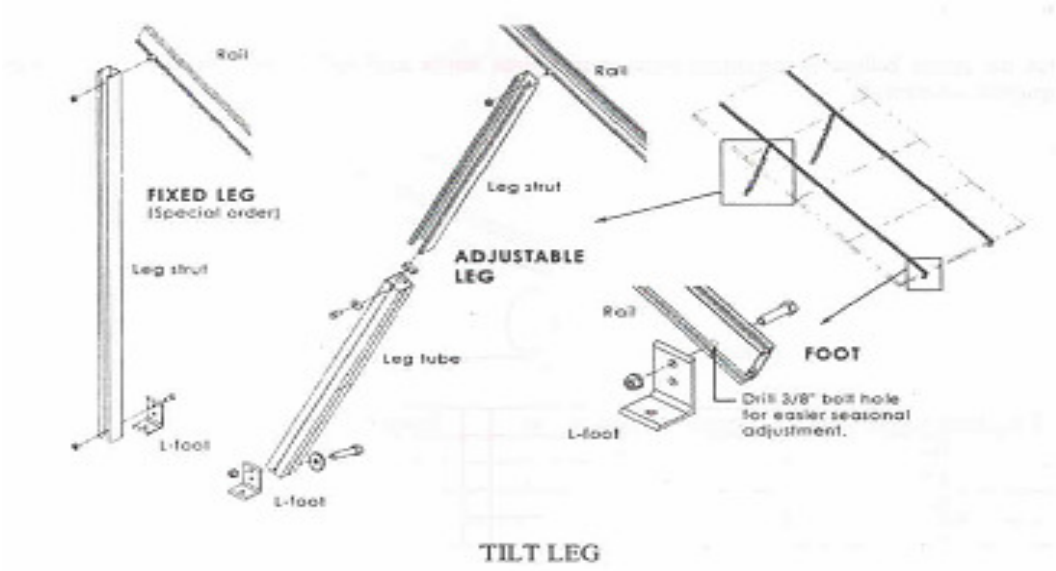
Always ensure that all bolts are secured tightly after alterations have been made.

A protractor can be used to determine if the correct angle has been acquired.



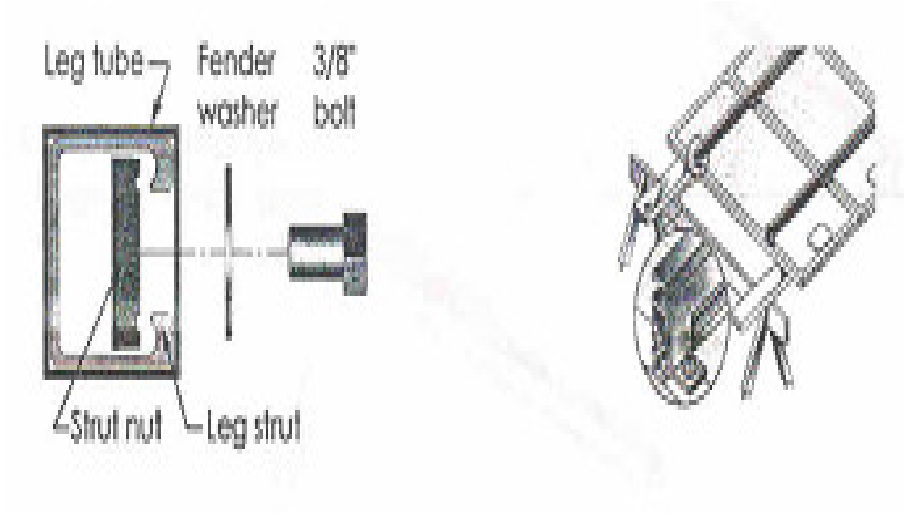
SUPPORT STRUCTURE
ASSEMBLY

1. Assemble the Unirac TLH High Profile tilt Legs as shown in the drawing below. The UniRac can easily be assembled in any order appropriate to the job site requirement.



TILT LEG

2. Use 3/8” hardware to assemble the UniRac and ¼” hardware to attach the PV modules to the UniRac



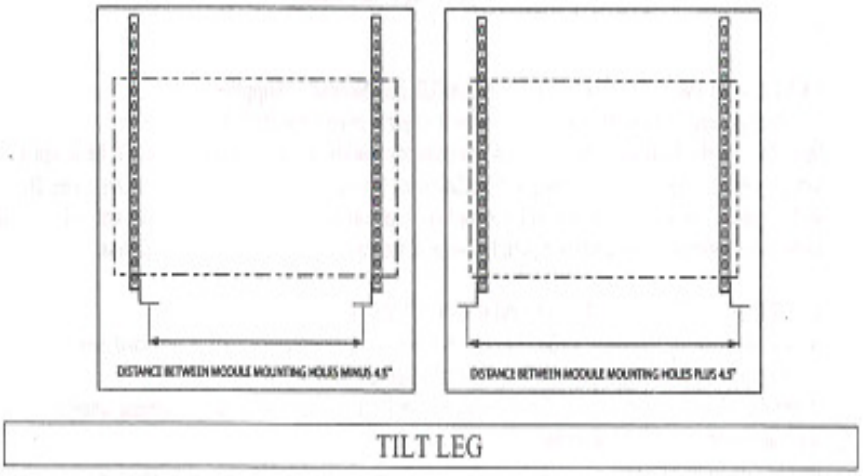
3. UniRac must be securely attached to roof rafter, ground footing or other secure structural feature. Simply screwing the UniRac to roof decking is not adequate to withstand high wind loads.

4.leaving as much space as possible at the bottom of the UniRac will minimize debris accumulation and snow load.

SUPPORT STRUCTURE

LOCATING MOUNTING FEET

5. The drawing below shows two options for setting the width of the Mounting feet. If possible, mount a PV module to the UniRails to determine the best attachment method

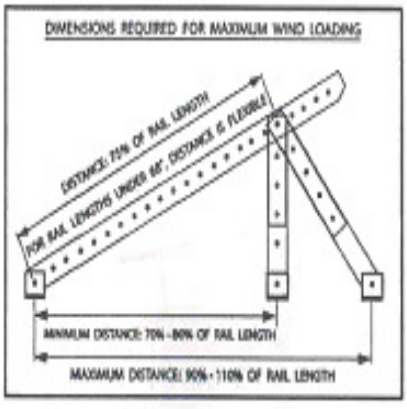


6. On UniRacs Tilt Leg Kits, rack tilt can be determined by

A- raising or lowering the Tilt Leg

B- Moving the Tilt leg up or down alog the UniRails,

C-Adjusting the distance between the lower and upper Mounting feet before final installation.



COMPLETED UNIRAC TLH HIGH-PROFILE TILT LEGS INSTALLATION (ADJUSTABLE LEG)

LIGHTNING PROTECTION

MEASURES

LEVEL 1-NO PROTECTIVE MEASURES-**NOT RECOMMENDED BY DULAS LTD**
Failure to provide protection measures against lightning strike risks damage to the equipment. In the event of lightning strike the roof mounted solar array, high voltage may be conducted towards the refrigerator system. This high voltage may damage the electronic components of the system.

LEVEL 2-LIMITED PROTECTIVE MEASURES (Normally Supplied)
We strongly recommend that at least this level of protection be installed-see figure 1.
Install an earth electrode (earth rod)(A) outside the building-the earth rod should be at least 2m long. Connect the earth rod with good quality wire (at least 6mm^2) to battery positive (wire B) and with separate similar wire to the Solar array and support structure (wire C). The earth wire should follow the shortest and straightest path between the support structure and the earth rod.

LEVEL 3- FULL LIGHTNING CONDUCTOR SYSTEM (Not Supplied)
Assess the risk of lightening strike. Look at other local building- are they fitted with lightening conductors? Ask local people if TV aerials etc often get struck?
If the installation is at high risk of lightening strike then an additional lightening conductor and separate earth rod should be installed-see figure 2.
In addition to level 2 protections, install a second earth electrode (D). The distance between the two earth electrodes must be more than their length. Erect an Air terminal of Lightning Conductor (E) next to the second earth electrode. The Air terminal must exceed the height of the Solar Array such that the Solar Array falls within 45^0 cone centered on the Air terminal-this is the area that is protected by the Air Terminal.

Figure 1.

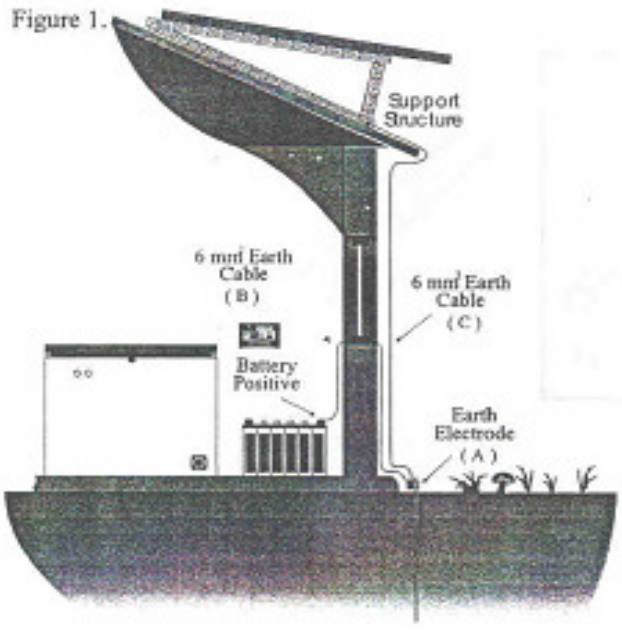
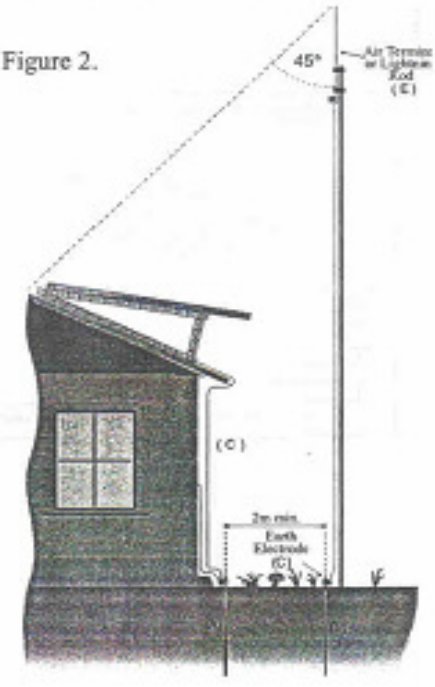


Figure 2.



PHOTOVOLTAIC CONTROLLER

INFORMATION

When using Lead-Acid batteries in photovoltaic systems it is important to protect them against overcharging which would otherwise cause excessive gassing and overheating, resulting in permanent plate damage and loss of electrolyte. The Photovoltaic Controller is installed into the system to perform this task. Over –charge prevention is achieved by limiting the battery voltage to a maximum of around 2.3 Volts per cel at 25^0c.This cause the charging current to fall naturally before gassing becomes a problem. The battery can be left charging at this 'float' voltage for long periods with minimal electrolyte loss. A periodic equalization charge is given to avoid plate sulphation and electrolyte stratification. The battery float voltage is temperature compensated. In order to measure temperature, a temperature sensor is built in to the controller. The controller should therefore be mounted as close as possible to the batteries.
The controller also has an automatic low voltage disconnect facility. In the event of the batteries not receiving charge, the refrigerator will be disconnected before permanent battery damage occurs, thus protecting system. Re-connection is automatic. A Liquid Crystal Display (LCD) indicates the state of charge of the batteries, and terminals are provided for the connection of batteries, photovoltaic panels and the refrigerator.

OPERATION

The Photovoltaic Controller is fully automatic in operation. See Steca manual for installation.

REGULAR FUNCTIONS

The display widow on front panel shows system and error message, the left button on front panel can be used to switch display windows or calling up settings and the right button is used as a manual load switch, or confirmation button in the programme mode. The three displays, which are the most relevant to the operation of the refrigerator, are as follows:

1. CORRECT OPERATION: Indicated by a smiling face in the display window. A sad face indicates a fault. The reference number in the display can then be looked up in the manual to give the meaning of the error and the cause/remedy.

2. STATE OF CHARGE: Indicated by the bar graph (SOC) and a percentage on the display. When the state of charge is 50% or less, icepacks should not be frozen.

3. LOAD DISCONNECTION: The refrigerator is disconnected when the state of charge drop to 30%. The SOC bar value, or the voltage value, flashes. The face looks sad until the reconnection set point is reached.

THE LCD ALSO PERFORMS VARIOUS OTHER FUNCTIONS. CONSULT THE MANUFACTURER'S HANDBOOK FOR FURTHER INFORMATION.

PHOTOVOLTAIC CONTROLLER

INSTALLATION

The unit should be installed in a dry location with clear space around it, to allow heat generated at the rear of the unit to be dissipated. The unit is fixed to the wall so that the terminals are at the bottom and the fins running vertically.

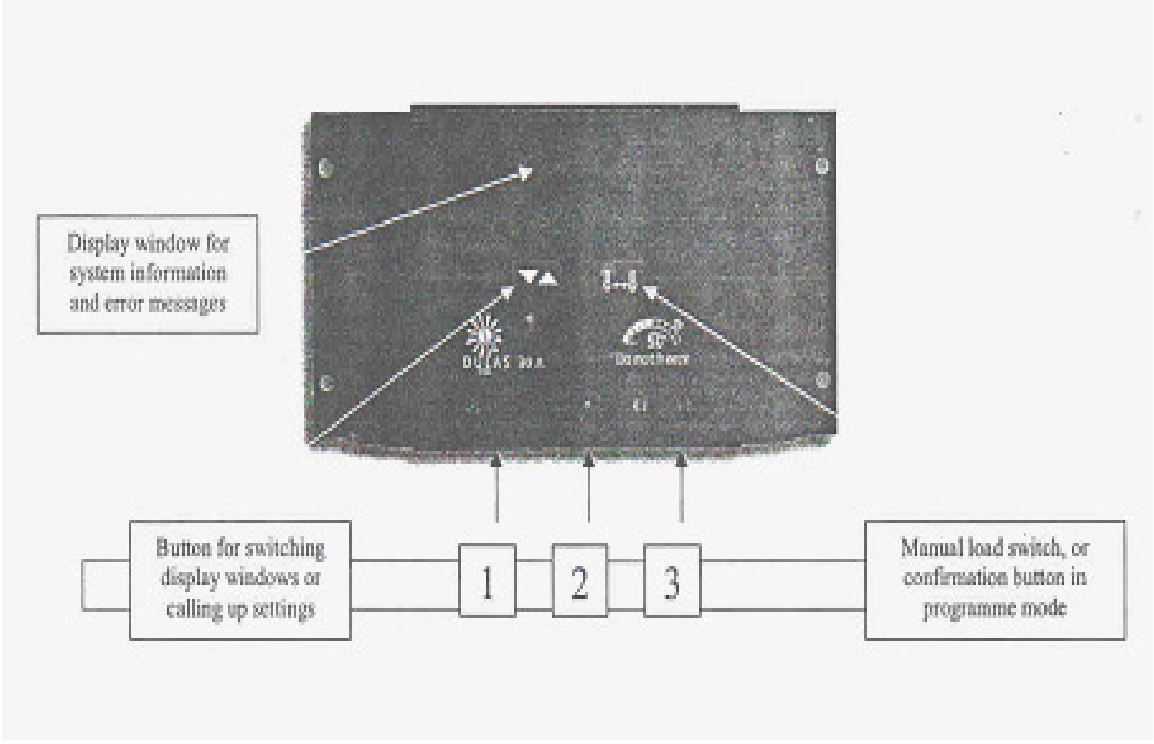
Installation instructions
1. Fix the Photovoltaic Controller to the wall with plugs and screws.

2. Connect the battery cable to the central pair of terminal on the unit (2). Taking care to ensure correct polarity (brown or red to +, blue or black to -).

3. The array output cable (a.2) must be connected AFTER the batteries, to the left hand pair of terminal on the unit (1) (brown or red to +, blue or black to -). BE AWARE OF LARGE VOLTAGES. Cover the array or connect at night.

4. The refrigerator is connected to the right hand pair of terminal (3) on the regulator, taking care to ensure correct polarity (brown or red to +, blue or black to -).

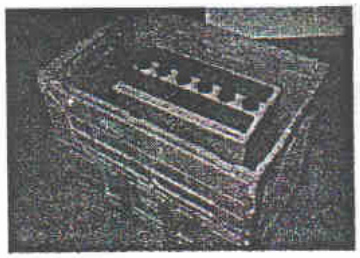
5. Support the cables using the clips provided.



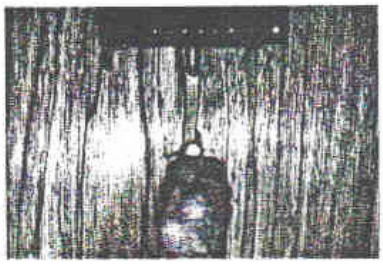
COMMISSION THE BATTERIES

CONNECT THE BATTERIES

THE BATTERY BOX MUST ALWAYS BE LOCATED IN A VERY WELL VENTILATED AREA AS THE BATTERIES GENERATE HYDROGEN, WHICH IS AN EXPLOSIVE GAS.



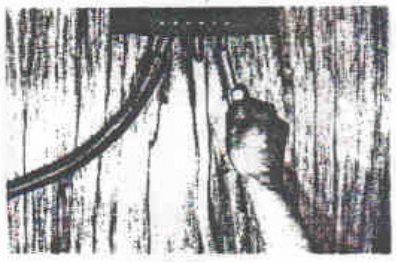
1. After choosing a final location, carefully place batteries into the empty box, ensuring not to lift by the terminal points. THE BATTERIES ARE NOW EXTREMELY HEAVY.



2. Connect the battery –to-regulator cable to the regulator FIRST, brown or red to + and blue to – THEN to the battery. Secure in place using the nuts, bolts and washers provided. Insert a spare fuse (d.7) into the fuse holder on the battery-to-regulator cable. Any problem refers to the manufacturers handbook provided.

3. Apply petroleum jelly or similar to each battery terminal-this help avoid corrosion.

4. Commence charging of the batteries immediately by connecting the solar array cable to the PV controller. **DO NOT CONNECT THE REFRIGERATOR,** as the batteries need an initial charging of two sunny days for optimum performance.



5. Once the batteries are ready for operation (after two good sunny days of charging), the refrigerator can be connected.

THE REFRIGERATOR /FREEZER

POSITIONING

DO NOT POSITION THE VC150 REFRIGERATOR/FREEZER IN DIRECT SUNLIGHT.
ENSURE THAT THE REFRIGERATOR IS WELL VENTILATED, ESPECIALLY THE VENTILATION GRILLS AND CONDENSER.
WE RECOMMEND LEAVING a 500mm GAP AT EACH END OF THE REFRIGERATOR
NEVER OBSTRUCT THE TEMPERATURE OR REGULATOR DISPLAYS
ENSURE THAT THE BATTERY BOX AND BATTERIES CAN BE INSPECTED WHEN NECESSARY
NEVER BLOCK THE CIRCULAR COMPRESSOR VENTILATION FAN AT THE FRONT

STARTING THE FRIDGE

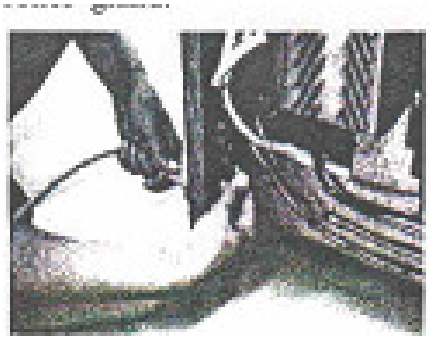
The VC150 refrigerator is designed for continuous operation, therefore an ON/OFF switch is not provided, as it is not necessary. The VC150 Freezer however, does not an ON/OFF switch to allow for defrosting? This is situated at the rear right of the cabinet, as viewed from the front, above the cable gland (see General Layout diagram)
The VC150 refrigerator/freezer is operational when the power cable is connected to the controller.

er cable to reveal 10 mm of brown or red (+) and blue or black (-)

b) Insert the cable into the black strain relief gland, located at the rear, see 'Cable Entry' in the General Layout Diagram.

.

c) Connect to + & - terminals on opposite side of the strain relief gland.



d) TIGHTEN THE TERMINALS SECURELY, TIGHTEN THE STRAIN RELIEF GLAND SECURELY.

THE REFRIGERATOR/FREEZER

LOADING

IN ORDER TO KEEP INTERNAL TEMPERATURE OPTIMUM AND MINIMISE ENERGY CONSUMPTION ONLY OPEN THE LID WHEN STRICTLY NECESSARY AND ALWAYS REPLACE INNER FOAM LIDS

The VC150 refrigerator /freezer has two components, see General layout Diagram:

1) The smaller freezer (ice pack) compartment to left.

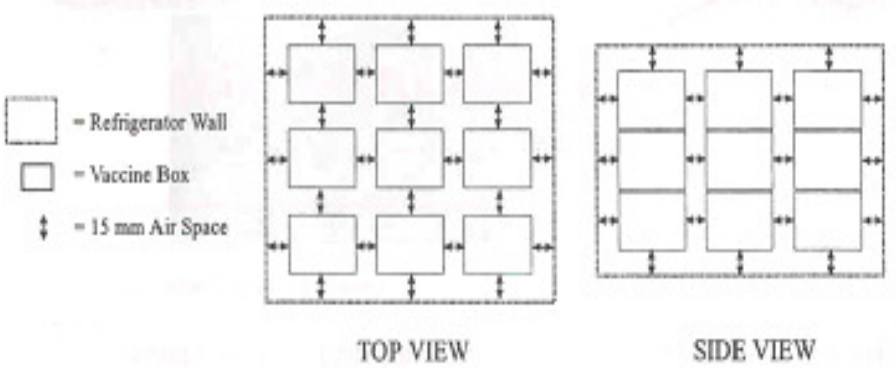
2) The larger refrigerator (vaccine) compartment to the right.

ICE PACKS: When frozen ice packs are needed; switch the freezer ON, insert ice packs with basket into the LEFT compartment. Ice packs must be in contact with the freezer compartment walls for effective freezing. A wire basket is provided to hold the ice packs against the walls of the compartment. Only three sided of the compartment can be used for freezing ice packs as the fourth has the thermostat sensor mounted on it. A small wire cage protects the sensor. Simply simply reaching inside the basket, and sliding the ice packs up and out of the ice freezing area remove ice packs. Frozen ice packs can be stored in the space inside the wire basket. The freezer can freeze nine ice packs simultaneously. Remember to switch freezer OFF when not in use – to save energy.

WARNING: STANDARD SYSTEMS ARE DESIGNED TO ONLY FREEZE 2.4 KG'S OF ICE PER 24 HOURS, FREEZING MORE WILL FLATTEN THE BATTERIES.

VACCINES: The refrigerator compartment situated to the RIGHT is in constant operation. The wire baskets in the refrigerator compartment are designed to prevent the contents of the compartment from touching the cold sides, and to encourage the circulation of air. Good air circulation will help the refrigerator to maintain an even temperature throughout the compartment. The contents of the compartment should be arranged to allow good air circulation. In order to save energy, try to keep the lid open for as short a time as possible. Try to allocate a certain space for each different type of vaccine, so that they may be located rapidly. Check the vaccine labels and adhere to any special requirements, always use before expiry date (store older vaccines on top).

WARNING: ALWAYS FOLLOW THESE VACCINE STORAGE GUIDELINES

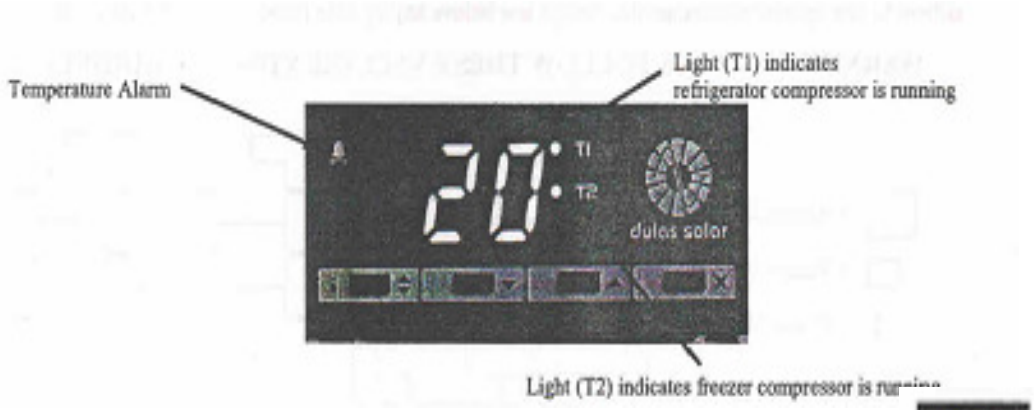


SINGLE FRIDGE CONTROLLER

The controller normally displays vaccine temperature. To see freezer temperature follow these steps:

Press		-the controller says hi
Hold		-the controller gives the high temperature (eg08)
Release		-the controller says Lo
Hold		-the controller gives the low temperature (eg03)
Release		-the controller says t1
Hold		-the controller give vaccines temperature (eg06)
Release		-the controller says t2
Hold		-the controller gives freezer temperature (eg -6)

Do nothing for 10 seconds and the display reverts to vaccine temperature.



The temperature alarm has a sound warming (beep). To cancel press 

ROUTINE MAINTENANCE

CHECK TEMPERATURE

The temperature the refrigerator should be checked each morning and afternoon. The temperature must be between 2^0 C and $+8^0$C.If the temperature is not within this range then something is wrong and the vaccines will be unusable. Cnsult the W.H.O. fault finding and repair of Photovoltaic (provided with each refrigerator).
Check the temperature by placing a thermometer next to the temperature sensor (situated at the rear of the right hand compartment) and closing the lid. After five minutes, remove the thermometer, read and record the temperature on a relevant data sheet.

CHECK LIGHTS

Check that the warning lights on the Photovoltaic charge regulator are not lit, and that operation is normal. If there is a problem then record this and refer to the W.H.O. fault finding and repair of the Photovoltaic refrigerators (attached).

DEFROSTING

If there is a build up of ice (5 mm or more) on the walls of the freezer, then it must be removed by defrosting. The refrigerator can be kept running or cleaned at the same time.

WARNING: NEVER REMOVE ICE WITH KNIVES OR SHARP OBJECT OR USE SCOURING POWDER, ABRASIVE CLEANERS OR STEEL WOOL AS THIS WILL DAMAGE THE METAL PLATING AND CAUSE CORROSION.

1) If the refrigerator is to be cleaned, move the vaccines into another fridge or a cold box, which can ensure the correct temperature, is sustained throughout the defrosting process.
2) Switch the freezer OFF (see general Layout diagram)
3) Open the outer Lid, remove the appropriate inner lid, leaving the freezer for at least 30 minutes to warm up.
4) When possible, remove ice with fingers or wooden /plastic tools.
5) Hand-warm water can be used to assist the defrosting process.
6) Dry the ice compartment after the ice has melted and cleans the vaccine compartment with soapy water, and then dries it carefully.
7) Clean the outer lid seal (talcum powder can be sprinkled on it prevent it from sticking).
8) Switch the Freezer backs ON and closes the lid.
9) After 2 hours check the temperature. Wait until the inside temperature has fallen to between 2^0C and $+8^0$C and the compressor has stopped running continuously.
10) Return the vaccines to the refrigerator and close the lids.

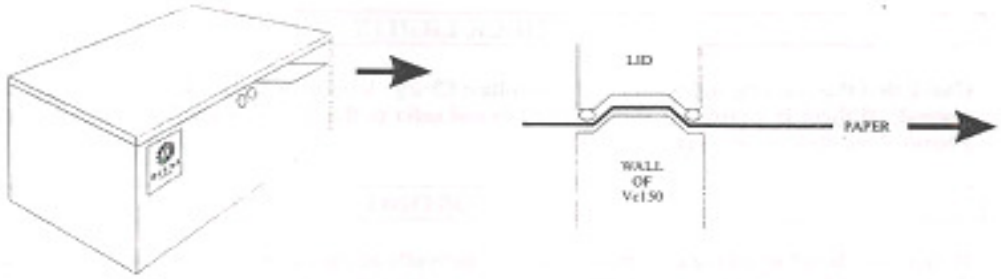
DEFROSTING MUST BE COMPLETED AS QUICKLY AS POSSIBLE TO PREVENT DAMAGE TO THE VACCINES

ROUTINE MAINTENANCE

CHECKING THE LID SEAL

The lid seal is the most likely area of heat penetration. If the lid hinges are wrongly aligned or the lid seal damaged, the system will have to work harder to maintain the vaccine temperature. When the batteries run out of energy the system will fail, therefore the lid seal must be checked regularly.

The easiest way to check your seal is to position a piece of paper between the lid and the wall, then after the lid, try to remove the paper.



Check the seal in this way around the entire lid, especially **the corners**. If the paper moves easily, then the lid seal needs attention, it may need to be re-guled or completely replaced, alternatively the refrigerator hinges may need adjusting so that the lid is sitting correctly.

CHECK FOR SHADOWS

Any shading of the array (solar panels) will reduce it's output, therefore the array must be checked three times in one day, at 7 am, 12 midday and 5 pm, to ensure all possible shade sources are eliminated.
Cut back any bushes or trees, which cause shading, seeking permission and explaining why firstly.

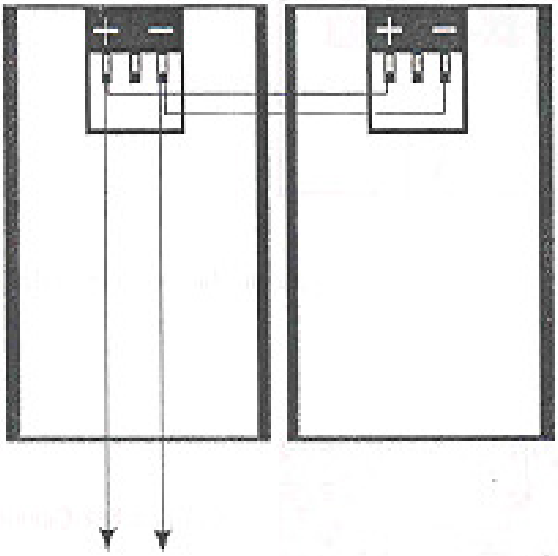
Move anything that has been placed in front of the array, and may block the sunshine falling on it.
If there have been any new buildings or structures erected which cause shadowing, then the array must be moved to an unshaded area.

CHECK ALL CONNECTIONS

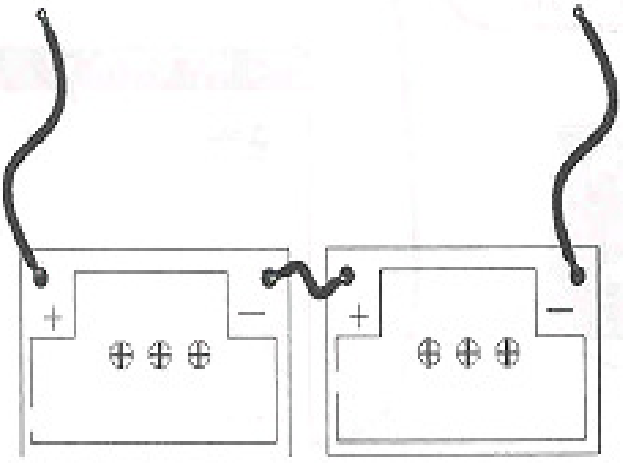
Check each electrical connection thoroughly, make sure every nut and bolt, are secured tightly.

MODULE AND BATTERY WIRING DIAGRAMS

2 x KD135 - 12 VOLT MODULE LAYOUT

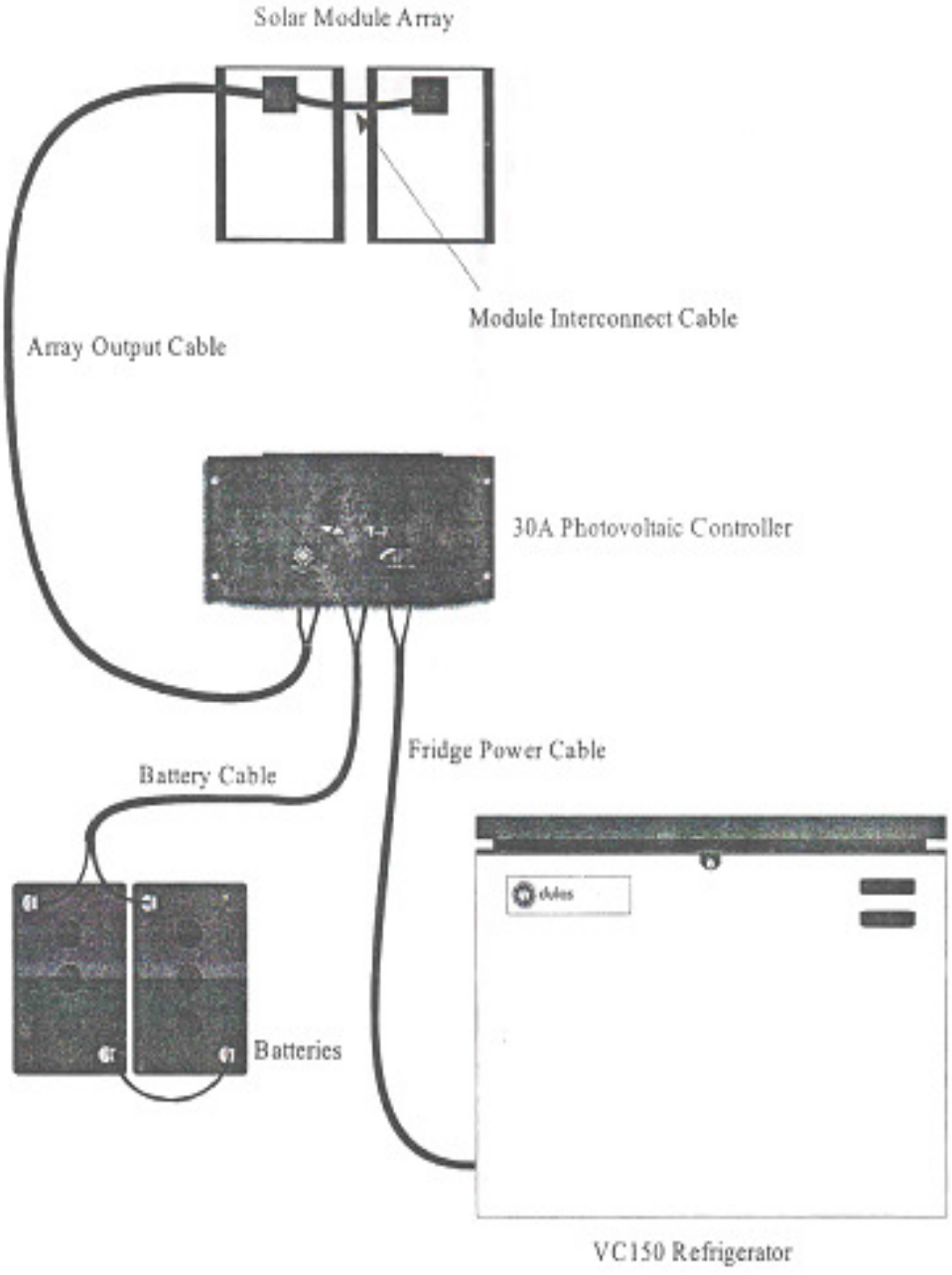


2 x 6 VOLT BATTERIES

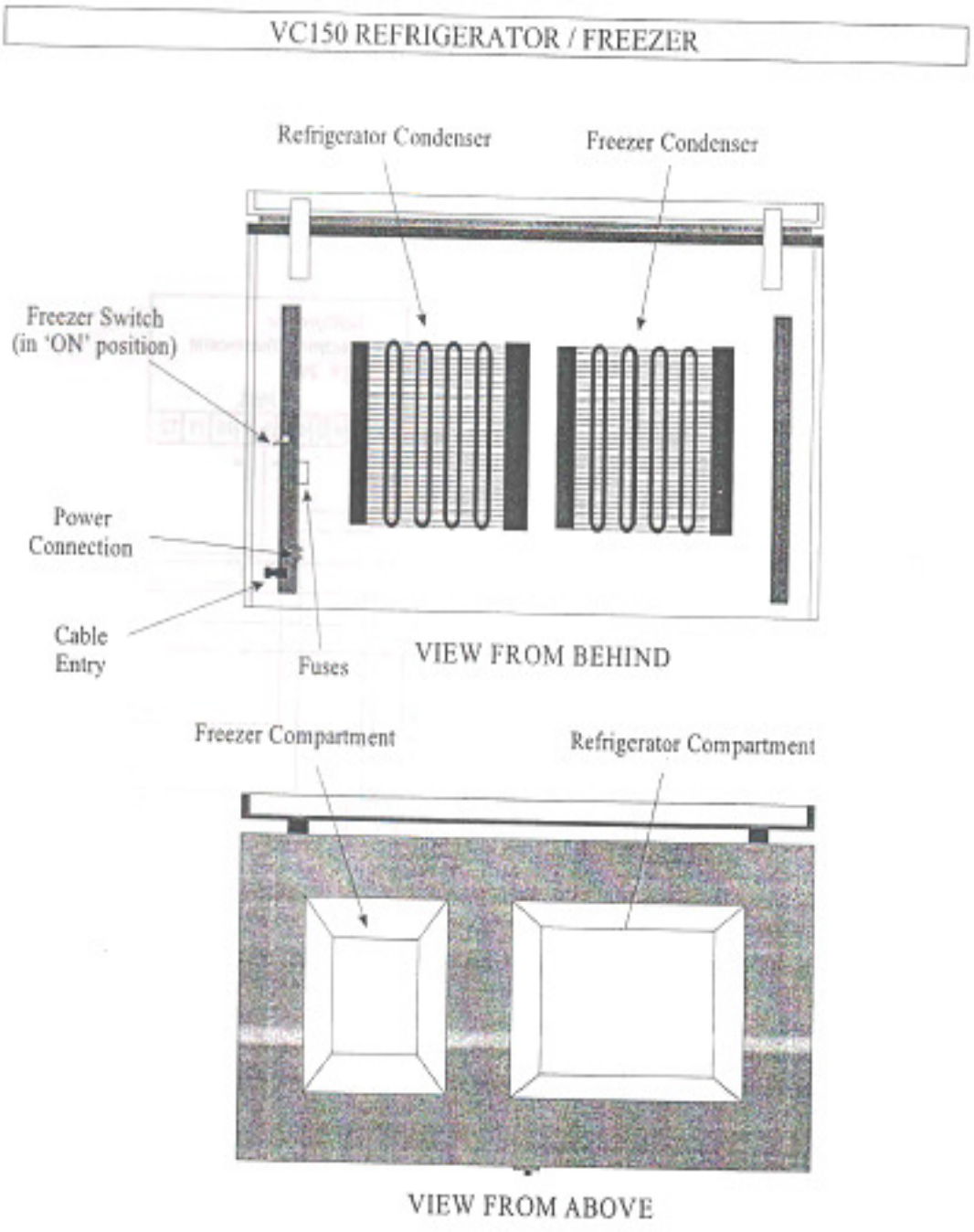


SYSTEM WIRING DIAGRAM

VC150 REFRIGERATOR / FREEZER



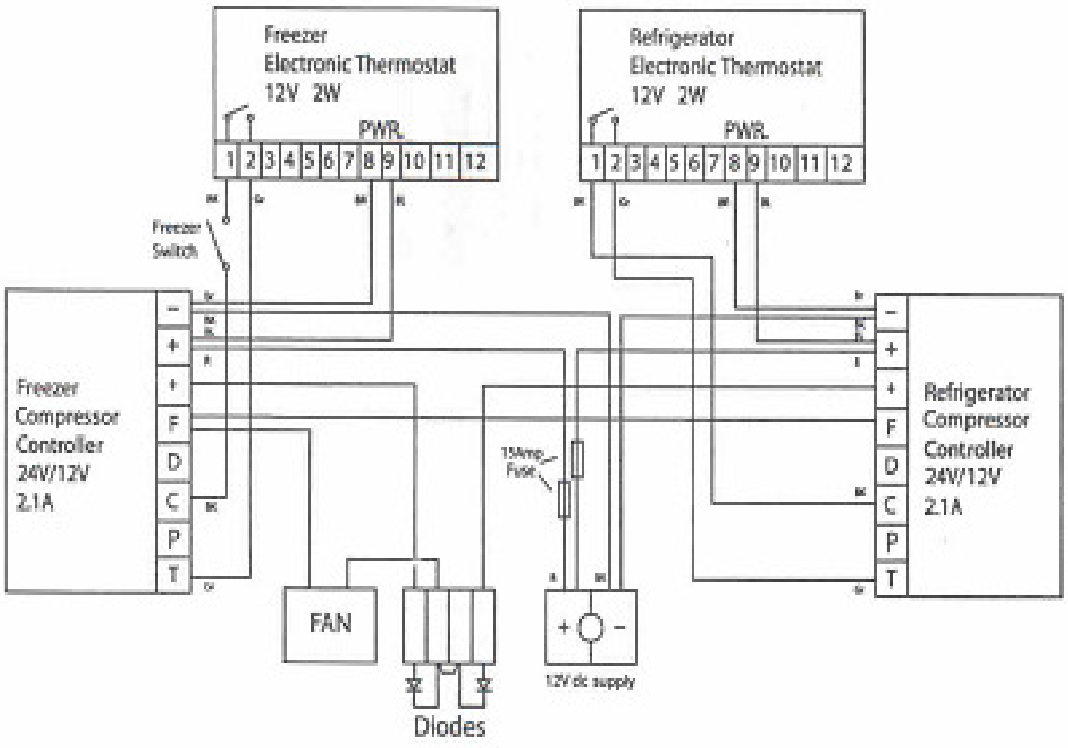
GENERAL LAYOUT DIAGRAM



ELECTRICAL CIRCUIT DIAGRAM

VC150 REFRIGERATOR / FREEZER

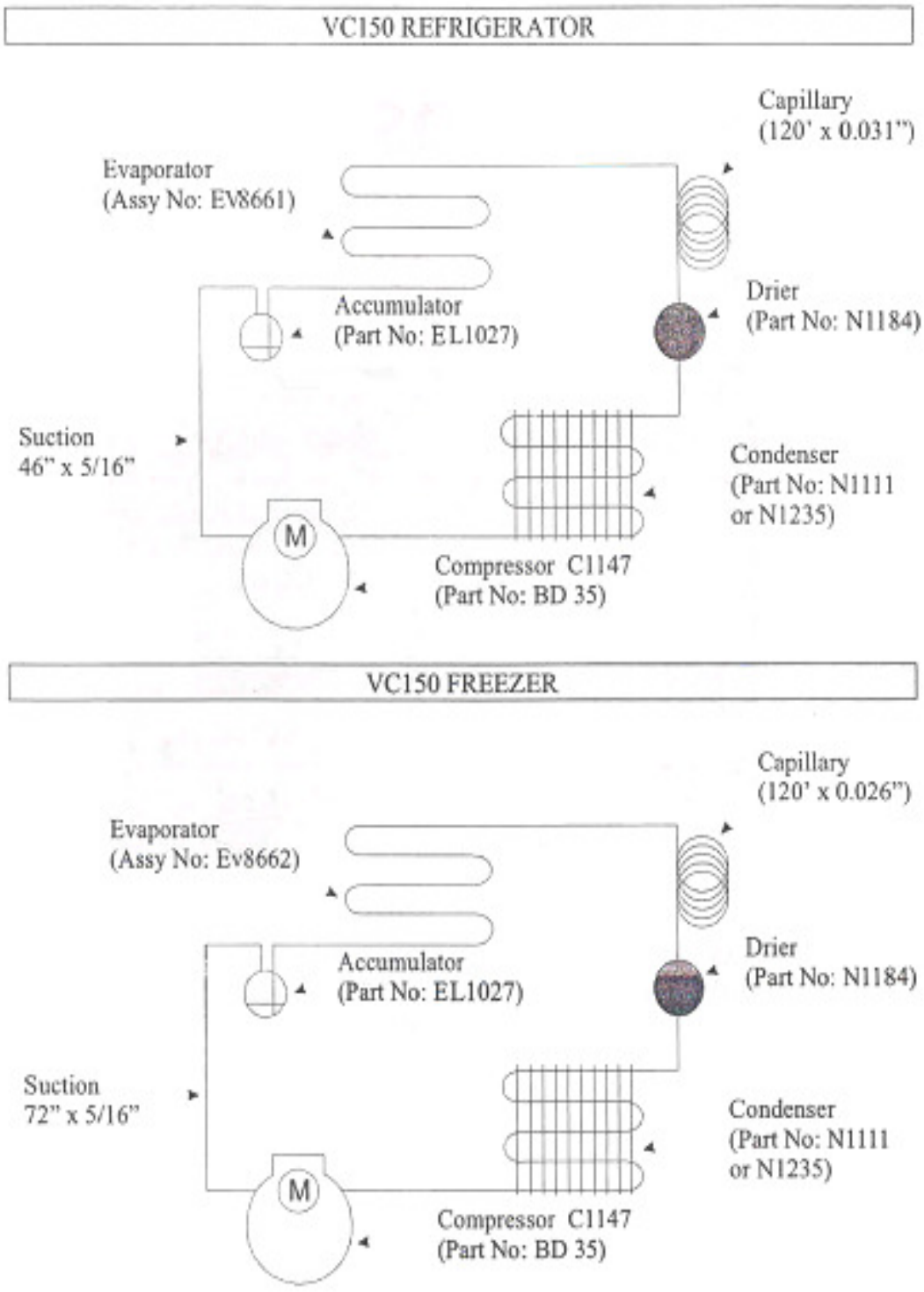
COLOUR	CODE
BLUE	BL
BLACK	BK
GREY	Gr
BROWN	BR
RED	R
WHITE	W



Parts List

Compressors C1147	BD 35
Compressor Controllers	E2128
Thermostats	CV731
Switch on Freezer only	CV465
Fan	E2076

REFRIGERATION CIRCUIT DIAGRAM



SECTION II

WORLD HEALTH ORGANISATION EXPANDED PROGRAMME ON IMMUNIZATION

FAULT FINDING & REPAIR

OF

PHOTOVOLTAIC REFRIGERATOR

A TECHNICIAN'S HANDBOOK

FAULT FINDING & REPAIR OF PHOTOVOLTAIC REFRIGERATOR

CONTENTS **Page No.**

PART 3: FAULT FINDING AND REPAIR TASKS

A: INTRODUCTION

B: HOW TO FIND A FAULT

1. Determine the symptoms
2. Carry out Preliminary check

C: FAULT FINDING CHART

Chart No. 1
Chart No. 2
Chart No. 3

D: FAULT FINDING AND REPAIR TASK DESCRIPTION

1. User maintenance tasks
2. Thermostat
3. Fuse Blown in compressor controller
4. Fuse Blown in charge regulator
5. Low state of charge of batteries
6. Wiring
7. Solar photovoltaic array
8. Compressor controller
9. Charge regulator
10. Condenser Fans
11. Cooling current
12. Compressor
13. System sizing

E: REPAIR TECHNIQUES

1. Introduction
2. Replacing a module
3. Adjusting a thermostat
4. Replacing a power cable
5. Replacing the charge regulator
6. Replacing the compressor controller
7. Replacing a condenser Fan
8. Replacing a battery

PART 4: RECORD-KEEPING

PART 5: USER TRAINING

GLOSSARY OF TERMS

ANNEX 1. Component layouts of commonly used photovoltaic refrigerator

ANNEX 2. Tools and measuring Instruments

PART 1: INTRODUCTION

A: Scope

This handbook is published by the World Health Organization Expanded programme on Immunization.

It is general handbook for use by service and repair technicians responsible for the maintenance and repair of solar photovoltaic powered refrigerator.These refrigerators are used for storing vaccines and freezing ice packs in health clinics.

This handbook applies specifically to 12 to 14 volt stand-alone photovoltaic powered refrigerators and should not be used for any other type of refrigerator. Stand-alone means here that the solar array does not power any other device (e.g. lights) and refrigerator it powered only from the solar array.

The handbook should be considered a supplement to maintenance and repair manual supplied by the solar refrigerator manufacturer, which define maintenance and repair activities specific to their model of refrigerator.

Each technician should have his or her own copy of this handbook. This handbook is one in a series of technician's handbooks for medical refrigerators and makes reference to other WHO handbooks on compression refrigerators. A complete list is shown on the inside front cover of this document. You should ensure you have copies of this also.

In addition to this handbook two others are available for solar Photovoltaic refrigerators:

- A USERS HANDBOOK for photovoltaic refrigerators.
- AN INSTALLATION HANDBOOK for photovoltaic refrigerators

You should ensure you have copies of the USERS HANDBOOK in case a user responsible for a solar refrigerator you visit does not have one.

It is not necessary for you to have a copy of the INSTALLATION HANDBOOK unless you are responsible for installing and repairing them.

B: HOW A SOLAR PHOTOVOLTAIC REFRIGERATOR WORKS

- A photovoltaic refrigerator is similar to an ordinary compressor refrigerator except that the compressor is powered from direct current (d.c) electricity supplied from a solar array. A photovoltaic refrigerator system compries the following principal parts:

- The solar photovoltaic array containing solar cells, which convert sunlight into direct current (DC) electricity. It has no moving parts and is a highly reliable component.

- Batteries, which are used to store electricity for periods when there is no sunlight.

- A charge regulator (an electronic unit), which is used to prevent the batteries from being damaged by too much electricity from the array or from too much electricity being drawn by refrigerator.

- A compressor, which sealed unit.

- A compressor controller which:
    - converts D.C. current electricity provided from the array and/or batteries into a form which will drive compressor.

    - prevents damage to the compressor if overloaded, and also protects the batteries against deep discharge.

These parts are connected together to make:

- A Solar Powered Battery Charger, and

- A battery powered refrigerator,

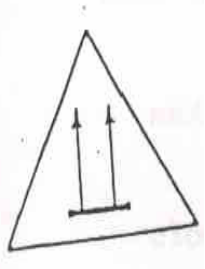
which when combined, becomes a refrigerator powered by sunlight, which we call a solar photovoltaic refrigerator (and can be a Solar Refrigerator, Photovoltaic Refrigerator or PV Refrigerator).

C: SAFETY CONSIDERATIONS

TECHNICIANS and USERS MUST ALWAYS take following precautions when transporting, handling, installing, maintaining and using photovoltaic refrigerator systems:

BATTERIES

BATTERIES CONTAIN ACID WHICH CAN CAUSE ACID BURNS ON SKIN OR BLINDNESS IF IN CONTACT WITH THE EYE. The acid will also damage clothes.



- avoid spilling or splashing battery acid especially in transport
- always keep the batteries upright
- carry batteries carefully (do not carry them on your head).
- attach batteries when transporting them.
- always use a funnel or plastic bottle with a spout to add distilled water.

BATTERIES ALSO GIVE OFF GASES WHICH ARE EXPLOSIVE:

- make sure that containers provided are well ventilated and that they are placed in a well ventilated room.
- keep naked flames and lighted cigarettes well away from batteries.
- always switch off power from the array and to the refrigerator before disconnecting the batteries (to prevent sparks). Provide well ventilated containers were not provided when installed.
- Keep un-insulated tools and metal jewellery away from batteries they may cause a spark if they come into contact with the terminals.

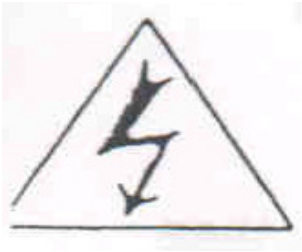
SOLAR ARRAY

Photovoltaic modules have a glass cover; always carry and Transport them carefully.

There is a risk of receiving an electric shock from a solar array.

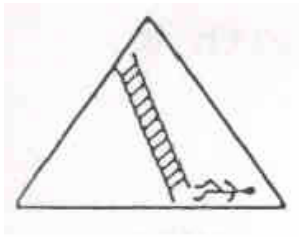
Always take the following precautions when undertaking servicing or repair work:

- cover the solar array with a sheet or cloth.
- use insulated tools.



Solar array are often mounted on a roof but must, however be cleaned regularly. There is risk of falling from a roof.

-make sure that the user has an easy and safe way of access to clean the array



-always use good ladders and position them firmly

-use crawling boards when walking on roofs.

FIRST AND MEASURES

- if battery acid splashes in your eye, wash your eye IMMEDIATELY with lots of clean water,
- if battery acid gets on your skin, wash IMMEDIATELY with soap and water.
- if you fall from the roof of high place, do not move until professional help arrives.
- make sure that someone at health center knows how to treat persons suffering from electrical shock.
- carry a first aid kit.

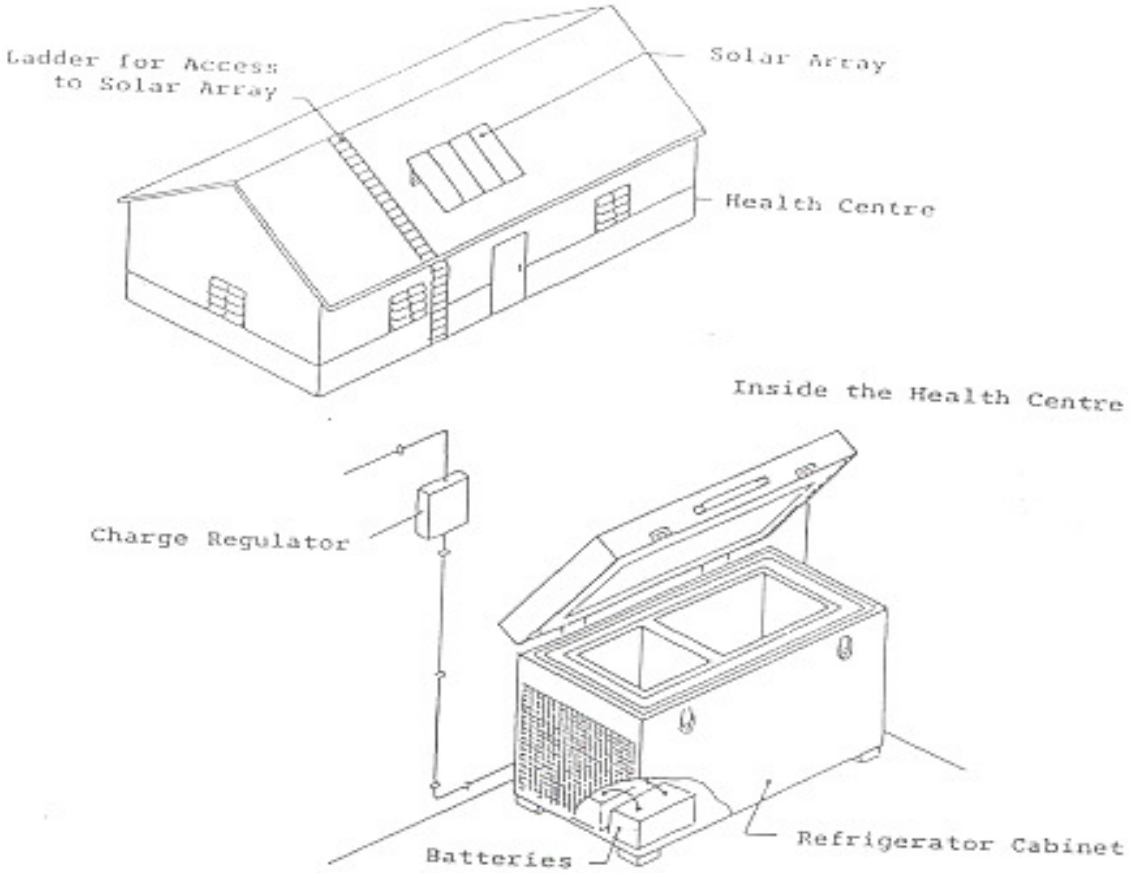
PART 2: MAINTENANCE AND SERVICING WORK

A PREPARATION

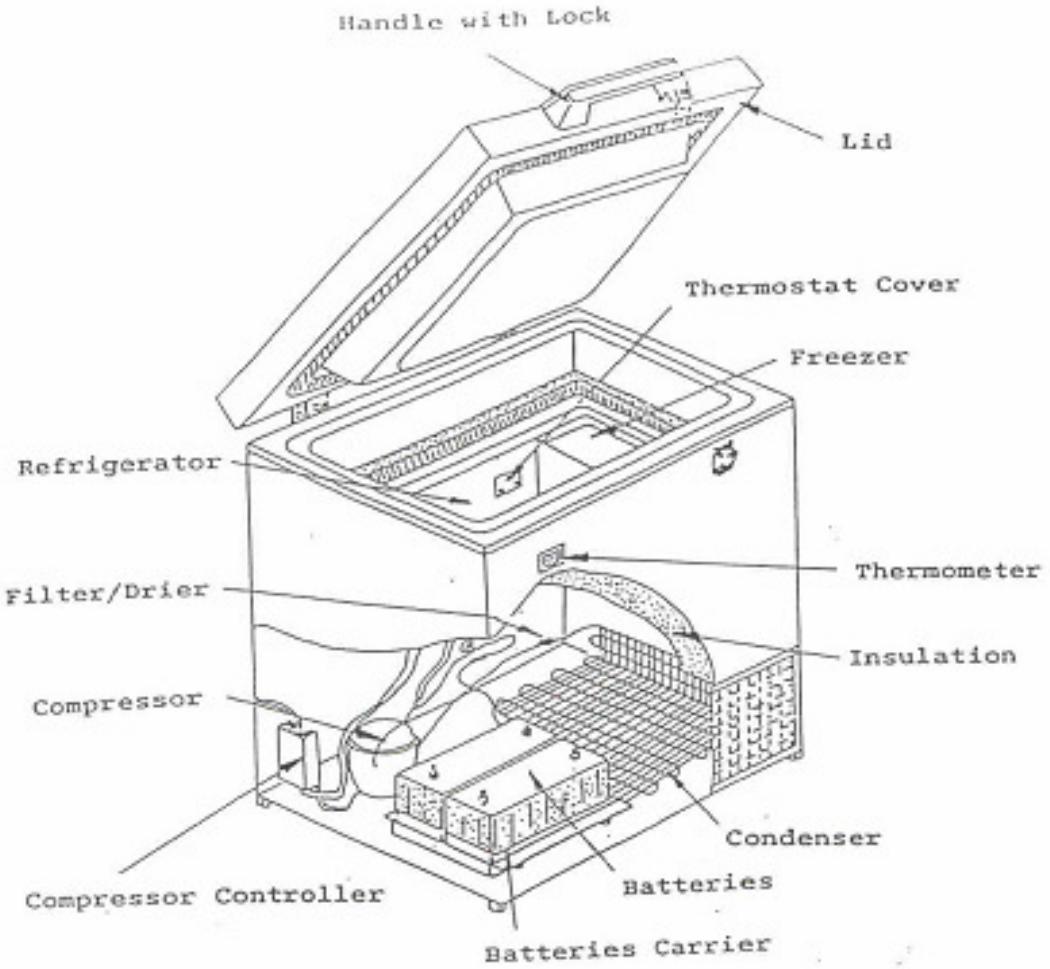
(a) Before starting service or repair work make sure you are familiar with the location of the components of the solar refrigerator (see pages 37& 38)

(b) Layouts of components in some commonly used solar refrigerators are shown in Annex1.Make sure you also have the manufacturers maintenance and repair manual for the refrigerator.

(c) REMEMBER
There is a risk of electric shock from the solar array. There is the risk of acid burn or explosion from batteries.
ENSURE THAT YOU TAKE THE SAFETY PRECAUTIONS DESCRIBED ON PAGE 34 & 36



COMPONENTS OF THE POWER SUPPLY OF
A SOLAR PHOTOVOLTAIC REFRIGERATOR



COMPONENTS OF A TYPICAL SOLAR
PHOTOVOLTAIC REFRIGERATOR

B: HOW TO MEASURE

1. TEMPEARTURE

Temperature is measured with thermometers. There are many different types of thermometers. The choice of thermometer should depend upon the degree of accuracy, the reliability, the response rate, the temperature range required and budget available.

1.1 Refrigerator and freezer temperature

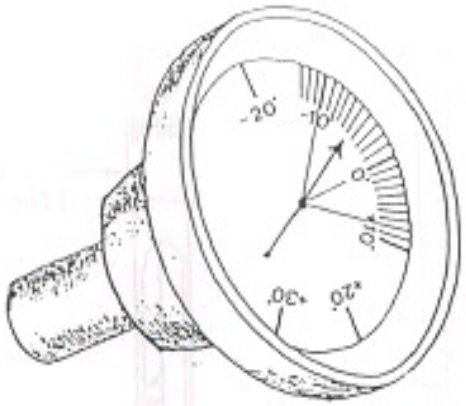
Temperatures are usually measured in the refrigerator and freezer compartments of photovoltaic refrigerators with low –cost, simple low precision bi-metal thermometers. This type of thermometer is robust, stable and simple to read.

It is easy to check the accuracy of a bi-metal thermometer by removing it from the freezer or refrigerator compartment and placing it alongside another thermometer for several minutes at room temperature. If the thermometer gives the same reading; then most likely they are reading correctly.

Thermometers used in the compartments of refrigerators frequently have red/and/or green ranges marked on the scale, which indicates the correct temperature range at which the compartments should be operating.

The procedure is to read the temperature directly from the scale, which should be marked in degree Centigrade (^{0} C).

REMEMBER: THE VACCINE COMPARTMENT OF A REFRIGERATOR SHOULD ALWAYS BE BETWEEN 0^{0}C AND 8^{0}C.



TYPICAL REFRIGERATOR THERMOMETER

TYPICAL REFRIGERATOR THERMOMETER

BATTERY TEMPERATURE

The temperature of the electrolyte in the battery cells must be measured with mercury in glass thermometer. The thermometer should have a range of not more than 0^0C to 8^0C;otherwise it will not be sufficiently accurate. The thermometer should be encased in a metal shell to protect it from breakage.

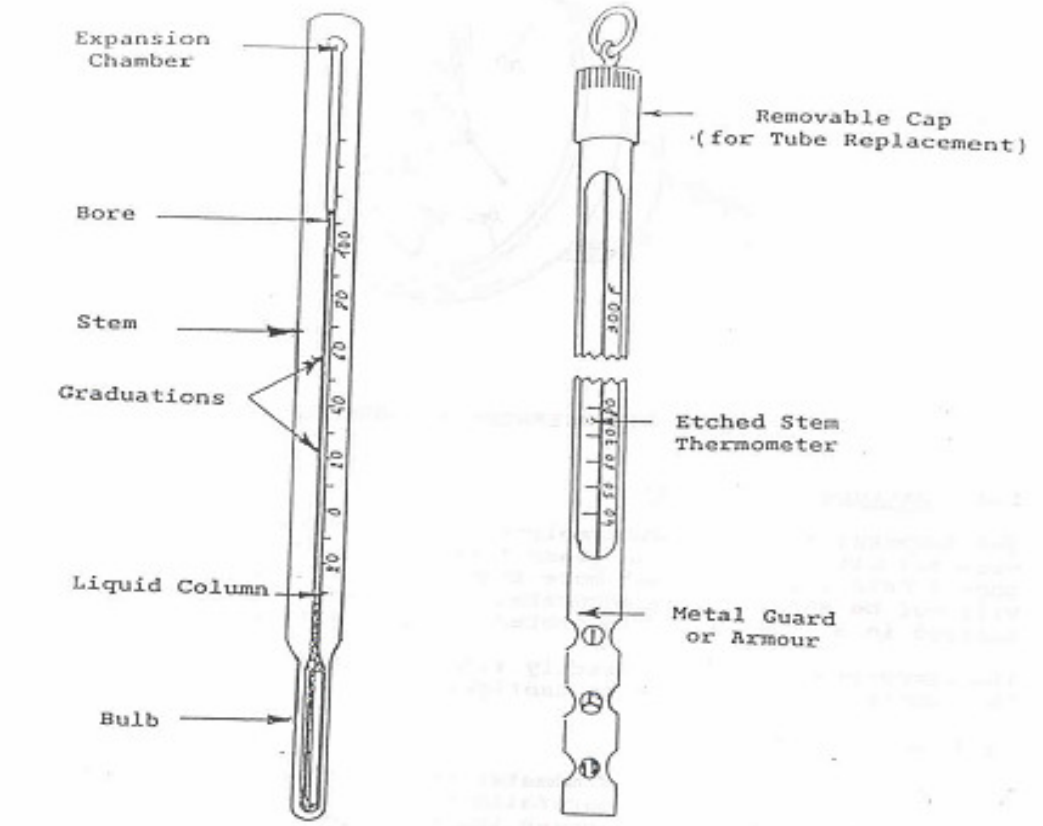
The temperature is read directly from the scale on the thermometer and should be in Centigrade (^{0} C).

To take a measurement:

1. Put the bulb of the thermometer in the electrolyte and hold it in the electrolyte carefully for about 30 seconds. (You must be careful not to press the thermometer bulb against the metal plates in the battery because they are delicate and easily damaged.)

2. Read the temperature directly from the thermometer.

3. After using the thermometer, wash it thoroughly in cool water. Do not use hot water, you may break the thermometer.



THERMOMETER TO MEASURE BATTERY ELECTROLYTE TEMPERATURE

2. ELECTRICITY

2.1 General

When doing faultfinding and repairs on photovoltaic refrigeral systems, it is necessary to measure the voltage, current and resistance at various points in the circuit.

The type of voltage measured is DC (direct current) volts and no AC (Alternating current) volts as is normally observed in the electrical supply of houses.

The type of current measured is DC (Direct current) amps and no AC (Alternating current) amps as is normally observed in the electrical supply of houses.

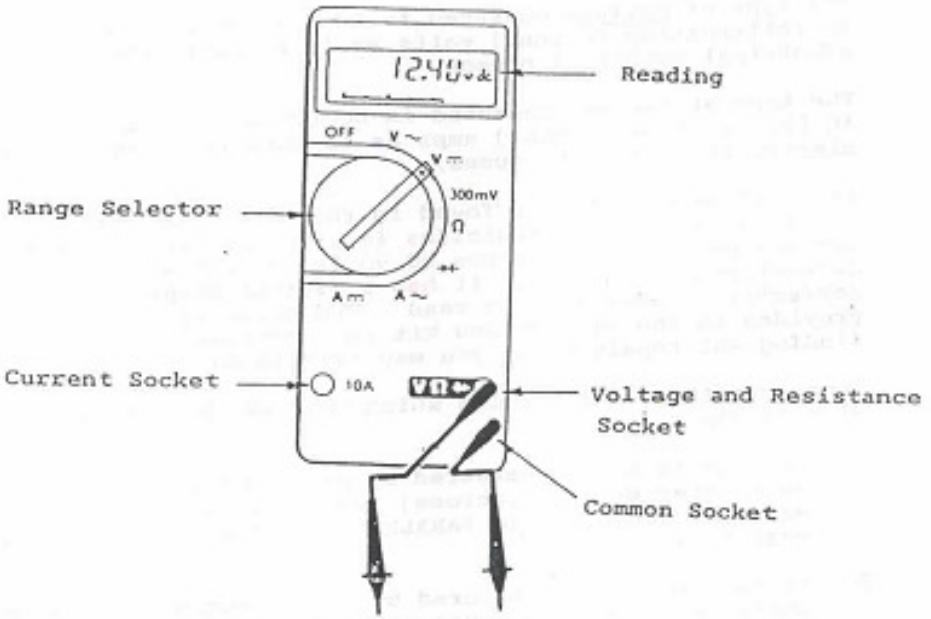
The instrument that is found in the UNIPAC maintenance kit supplied to repair technicians is a millimeter. This millimeter has the capacity to measure DC volts, AC volts, resistance, AC current and DC current. It has a digital display and when set correctly is very easy to read. The accuracy of the instrument provided in the maintenance kit is sufficient for all faults finding and repair tasks you may need to do.

There are three basic rules, which MUST BE OBSERVED when measure in electricity.

1. Voltage is always measured by putting the probes of the millimeter between (across) two points in the circuit. The meter is connected in PARALLEL with the circuit, which you are measuring.

2. Current is always measured by disconnecting the two points where you wish to measure current and putting the probe between the two disconnected points of the circuit. The meter is connected in SERIES with the circuit you are measuring.

3. Resistance can only be measured when the power has been removed from the circuit.



TYPICAL DIGITAL MULTIMETER

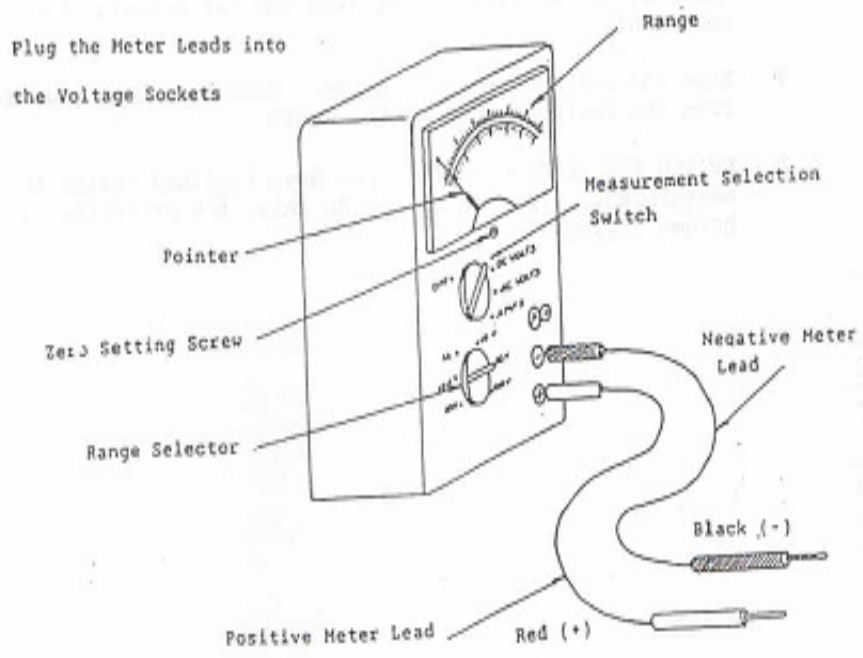
2.2 Measuring Voltage

Use a millimeter or DC Voltmeter to measure DC voltage in the following manner:

1. Set the millimeter to measure DC voltage

2. Set the range on the meter so that it included the voltage that you expect to measure. For example, if you expect that the voltage you are going to measure will be about 12 V, set the range to 0-20V.

3. Plug the meter leads into the meter sockets. Make sure that the negative (black or -) lead goes into the negative (or 'common') socket, and that the positive (red or +) lead goes into the positive socket.



4. Make sure that the meter is switched ON and that it has charged batteries inside. Some types of millimeter are switched on automatically when you turn the measurement selection knob.

5. (a) If the meter is an analogue type as shown on this page, make sure that the needle points to 0 volts when the metal tips of the metal leads are not touching anything. If the needle does not point to 0 volt, adjust zero setting screw until it does. Look at the scale with straight in front of you so that you can read it accurately. Do not look from an angle.
   (b) If a meter is a digital type, make sure it read 0.0 volts when you touch the meter leads together.

6. Touch the metal tips of the meter leads to the electric terminals across which you want to measure the voltage. Be careful not to short-circuit the terminals by touching both the terminals with the same probe. If you short-circuit the terminal large currents may flow and cause damage to components.

7. Read the voltage from the meter. Make sure that you read from the correct range on the scale.

8. SWITCH THE METER OFF after you have finished taking the measurement. If you do not do this, the batteries may become drained.

2.3 MEASURING CURRENTS

2.3.1 Use a millimeter or DC ammeter to measure current in the following manner:

1. Set the millimeter to measure current. The setting on the selection knob may be labeled “current”, ”amperes”, ”amps” or just “A”.

2. Set the range so that it included the current that you expect to measure. If you expect current to be about 5A,set the range to 0-10 A.

3. Plug the meter leads into the correct sockets in the meter. Make sure that the negative (black or -) lead goes into the negative (or “common”) socket and that the positive (red or +) leads goes into the current (A) socket.

4. Make sure that the meter is switched ON and that it has batteries inside. Some types of meter are switched ON automatically when you turn the measurement selection knob.

5. If the meter is an analogue meter as shown above make sure that the needle points to 0 amps when the metal tips of thermometer leads are not touching anything. If the needle does not point at 0 amps, adjust zero setting screw until it does. Look at the scale with it straight in front of you so that you can read it accurately. Do not look from the angle.

6. Switch OFF the circuit. Disconnect at one terminal the wire through which you want to measure the current.

7. If you have disconnected the positive wire, connect it to the black (common) meter lead. If you disconnected the negative wire, connect it to the red lead. To make the connection use a crocodile clip to hold the lead and the wire together.

8. Touch the metal tip of the other metal lead to the terminal from which you disconnected the wire.

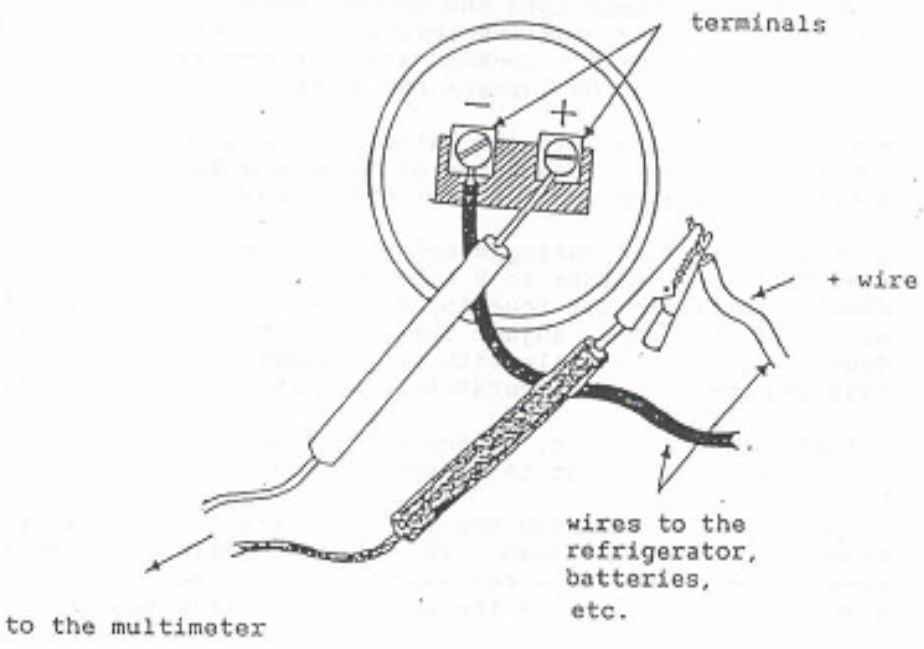
9. Switch ON the circuit. Be careful not to make a short-circuit between the terminals by accidentally touching both terminals.

10. Note down the reading. Make sure you read from the correct range on the Scale if the meter is an analogue ammeter.

11. SWITCH THE METER OFF after you have finished taking the measurement so that you do not drain the batteries.

12. SWITCH OFF the circuit and reconnect the wire to its terminal.

13. Switch back ON the circuit.



MEASURING CURRENT

2.3.2 Using a current shunt with a millimeter or milivolt meter to measure current.

1. Switch OFF the system. Disconnect the wire at the terminal where you want to measure the current.

2. Select a current range that included the current yu expect to measure. Connect the shunt between the disconnected wire and the terminal and connect the probes of the millimeter to each terminal of the current shunt.

3. Select the mili-volt range on the millimeter which includes the mili-volt range identified on the current shunt, and proceed to measure the mili-volt across the current shunt as shown below.

4. The value read on the meter in mili-volts is converted to current (amperes) by multiplying this number by the number of amperes, which are equivalent to 1 mili-volt as indicated on current shunt.

Example:

Current shunt is marked 20 A. 200 mV

Hence 200 Mv is measured if 20 Amps is flowing the wire so, 1 mV is measured if 20 Amps is flowing in the wire (We divide by 200 to find the equivalent of 1 mV).

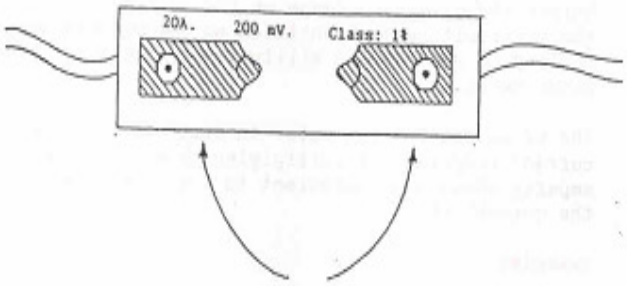
So, 1MV= 0.1 Amp

If, for example the reading on millimeter is 55 mV

Across the shunt connections we have 55 mV (mili-volts)

Therefore in the circuit we have 55 * 0.1 Amps= 5.5 Amp

Current in circuit= 5.5 Amps



Measure the millivolts between these metal contacts

USING A CURRENT SHUNT

3. RESISTANCE

In fault finding and repairs of photovoltaic refrigerator systems it is necessary to measure the electrical resistance of the compressor windings and to determine if these windings are adequately insulated. The millimeter provided in the UNIPAC maintenance kit (or any other millimeter) is adequate for these tasks if the following procedure is observed.

1. Switch OFF the refrigerator.

2. Disconnect the wires from the positive terminal of the battery.

3. Set the millimeter to measure resistance.

4. (a) If you want to measure small values of resistance, set the range on the millimeter to 'one ohm' (which may be indicated 1)

   (b) If you want to measure high values of resistance set the range to 100,000 ohms or the largest range of resistance on your millimeter.

5. Switch ON the meter, plug in the meter leads to the correct sockets in the meter, and hold the tips of the probes together.

6. If you have an analogue meter adjust the meter so that the resistance between the probes reads zero. If you are unable to adjust the meter so that it reads zero, this means that the batteries in the meter are discharged and should be changed.

7. Holds the probes between the two points in the circuit where you want to measure resistance.

8. Read the resistance value directly on the meter if you have a digital meter, or on the appropriate scale if you have an analogue meter.
9. SWITCH THE TIMER METER OFF when you have finished.

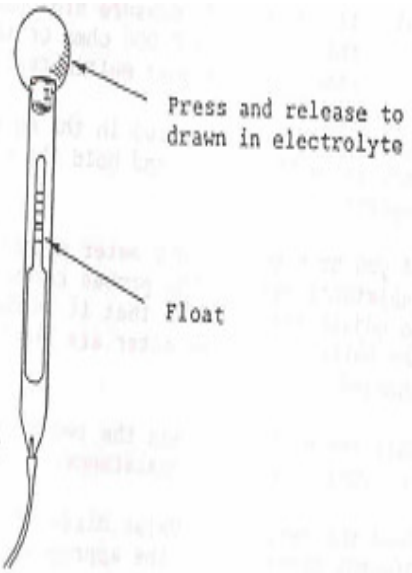
4: STATE OF CHARGE OF BATTERIES

The amount of energy stored in a battery at any time is called the “State of Charge”. The “State of Charge” can be approximately estimated by measuring the voltage across the battery terminals when battery is being discharged under know conditions of current and temperature and is the only way to measure the State of Charge of sealed batteries.

The State of Charge of lead-acid batteries that are not sealed can also be determined by measuring the specific gravity of the electrolyte (the acid and water mixture in the battery) and the temperature of the battery. This is the most practical way to measure the state of charge of batteries, which are not sealed.

The following procedure explains how to do this:

1. Top up the battery with clean distilled water to the maximum level indicated on the battery.
2. Leave the battery for one hour to allow the acid and water to mix.



HYDROMETER FOR MEASURING THE SPECIFIC GRAVITY

3. Insert the hydrometer into the electrolyte in a cell of the battery, squeeze the rubber bulb, and draw enough electrolyte into the hydrometer to make the indicator float freely.

4. Record the specific gravity reading as indicated by the float and adjacent scale.

5. Return the electrolyte to the small cell in the battery being careful not to spill it.

6. Insert a thermometer (mercury in glass type) into the battery so that the bulb of the thermometer is covered in electrolyte but not touching the battery plates. Wait until the temperature shown has stabilized and record the electrolyte temperature.

7. Using the table below, which shows the temperature correction to specific gravity, record the correction value.

Temperature Correction to Specific Gravity Readings (to 15^0 C)

Electrolyte Temperature ^{0}C	Correction to specific Gravity
55	+0.028
50	+0.024
45	+0.021
40	+0.017
35	+0.014
30	+0.010
25	+0.007
20	+0.003
15	0.000
10	-0.003
5	-0.007
0	-0.010

TEMPERATURE CORRECTION TABLE

Example

For 30 degrees centigrade the correction is +. 010

Add this value to the reading obtained from the hydrometer.

This answer gives the specific gravity of the electrolyte if at 15 degrees Centigrade.

8. Convert the specific gravity into a measurement of the States of charge by looking at the table below.

Specific gravity at 15 degrees C Vs
State of charge

Specific Gravity	State of Charge %
1.225	100
1.216	90
1.207	80
1.198	70
1.189	60
1.180	50
1.171	40
1.162	30
1.153	20
1.144	10
1.135	0

STATE OF CHARGE TABLE

Example:
A specific gravity of 1.202 corresponds to a state of charge of between 70 and 80 %.

5: TILT AND DIRECTION OF PHOTOVOLTAIC ARRAY

5.1 General

The tilt of a photovoltaic array is the angle created between the surface of the array and the horizontal.

The tilt should be approximately equal to the latitude of the site, except in case where the latitude is less than 5^0 either North or South, in which case the tilt should be maintained at 5^0.

A line normal to the surface of the array points out the direction of a photovoltaic array.

A photovoltaic array should always slope towards the South when mounted in the Northern hemisphere and always slope towards the North when mounted in the Southern hemisphere.

For photovoltaic refrigerator installations, neither the tilt or direction needs to be measured with any great accuracy, but both should be correct within 10 degrees.

Array tilt may be measured with an inclinometer, which is an instrument designed especially to measure slope or a spirit level and ruler or tape measure and some simple calculations. These methods are described in the INSTALLATION HANDBOOK for Photovoltaic Refrigerators.

The best method however is to use a TEMPLATE (triangle) and SPIRIT LEVEL as described on the next page.

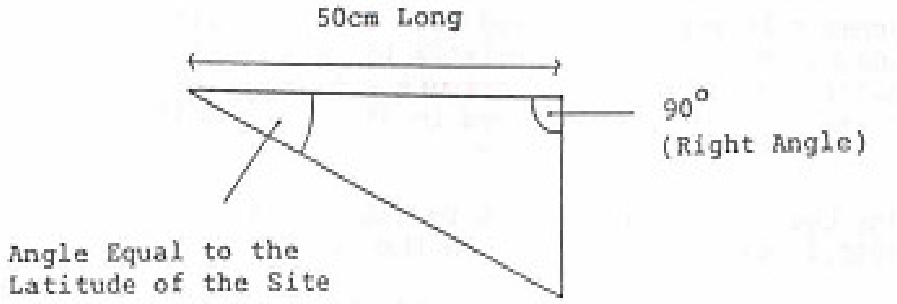
Array direction may be measured with a compass.

5.2 HOW TO MEASURE TILT WITH A TEMPLATE AND SPIRIT LEVEL

1. If you do not already know, find out the approximate latitude of the place where the refrigerator is installed.

2. Cut out a triangle from cardboard if you do not plan to use it often, or from wood if you have several solar arrays to check. (DO NOT MAKE IT FROM METAL). The triangle should be have:

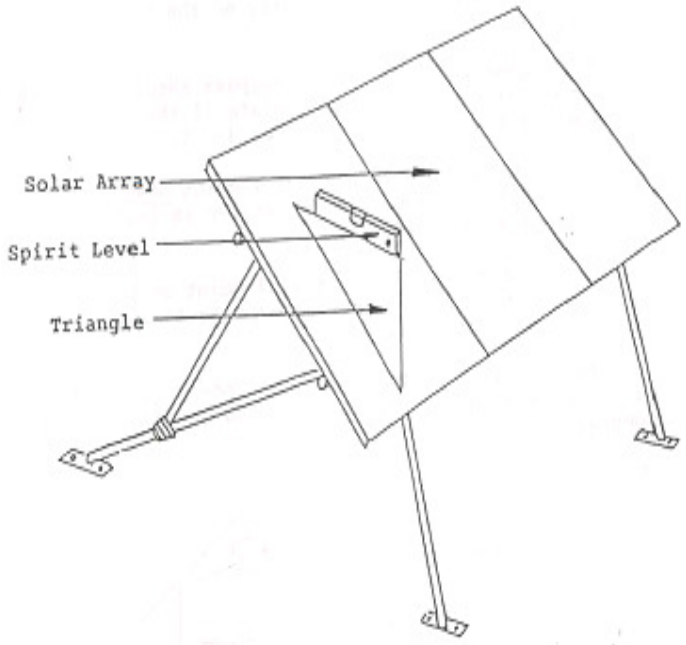
   - one side 50 cms long
   - one angle of 90 degrees, and
   - one angle equal to the latitude where the refrigerator is installed.



TRIANGLE TO MEASURE TILT

3. Place the triangle on the surface of the array so that it is parallel to the sloping sided of the array and so that the angle, which is equal to the latitude, points away from the equator.

4. Place a spirit level on the upper edge of the triangle. If the bubble in the level indicator shows that it is level, then the photovoltaic array is set an angle, which is equal to the latitude.



TRIANGLE AND SPIRIT LEVEL TO MEASURE TILT

5.3 How to measure direction

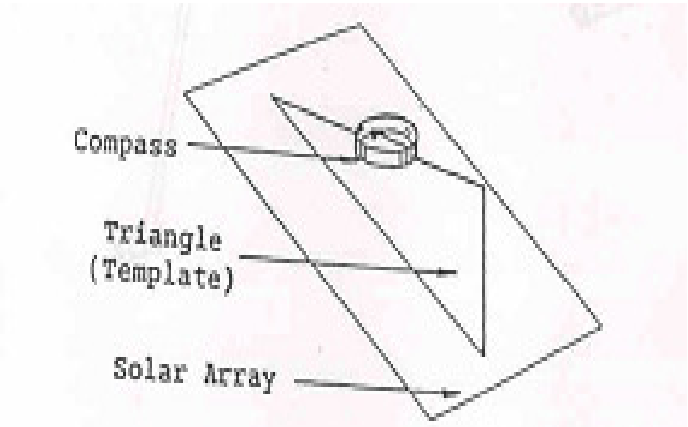
The only practical method to measure direction of the array with sufficient accuracy is with a compass. The procedure is as follows:

1. Place the cardboard or wooden template, which you used to check the tilt of the array on the surface of a module so that it is parallel to the sloping sides of the module and so that the angle on the template, which is equal to the latitude, points away from the equator.

2. Place the compass horizontally on the top edge of the template.

3. The magnetic needle on the compass should point along the line of the edge of the template if the array slopes (faces) towards the equator, as it should. Also note that:
   - The magnetic needle will point down the slope of the panel. If your refrigerator is installed in the southern hemisphere.
   - The magnetic needle will point up the slope of the panel If your refrigerator is installation is in the Northern hemisphere.

4. The direction of the array on It needs to be positioned to within an accuracy of about 10^0 based on measurements with a compass.



MEASURING THE DIRECTION OF THE ARRAY WITH A COMPASS AND TEMPLATE (TRIANGLE)

6: OPEN AND SHORT CIRCUIT MEASUREMENTS ON THE PHOTOVOLTAIC ARRAY

Two simple measurements are possible to show whether a photovoltaic array is prating correctly. These are the measurement of SHORT CIRCUIT CURRENT AND OPEN CIRCUIT VOLTAGE.

Measurements are made as follows:

6.1 Using a millimeter or voltmeter to measure open-circuit voltage (Voc)

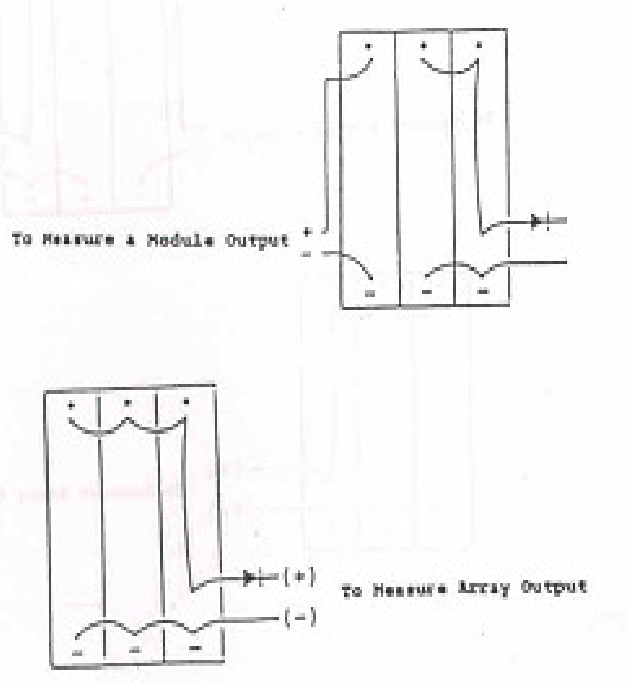
1. To test the solar array or one of the solar module in the array, you need to be able to measure the open-circuit voltage (Voc).

2. Measure Voc at around 12 noon on a very sunny day.

3. Voc is the voltage across the two output terminals when no electrical current is flowing. So you must disconnect one wire from the terminals. If you are measuring Voc for the solar array, disconnect one solar array output wire from the terminal box .If you are measuring Voc for one of the solar modules, disconnect the module from the solar array at the module box.

4. After you have disconnected the output wires, measure the voltage across solar array or module output terminals.

5. Reconnect the wires to the correct terminals after you have finished.



6.2 Using a millimeter or ammeter short-circuit current (Isc)

1. To test solar array or one of the modules you need to be able to measure the short-circuit current (Isc).

2. Measure Isc around 12 noon on a very clear sunny days and during a long period of uninterrupted sunshine (no clouds).

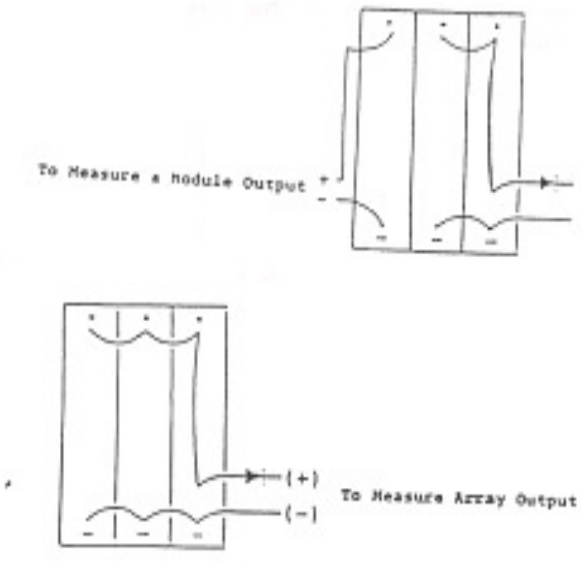
3. Isc is the electrical current flowing between the two output terminals when they are short-circuited by the millimeter or a shunt. You must disconnect one output wire from the terminals when you make this measurement.

   - If you are measuring Isc of the solar array disconnect a solar array output wire from the array junction box.

   - If you are measuring Isc of one of the solar modules disconnect the module from the solar array at the module junction box.

4. After you have disconnected the output wires, measure the current between the solar array (or module) output terminals.

5. Reconnect the output wires to the correct terminals after you have finished.



C: MAINTENANCE AND SERVICE TASKS

C.1 Introduction

The service tasks described here should all be done every time you visit a solar refrigerator.

BEFORE YOU START THE SERVICE TASKS DO THE FOLLOWING:

a) Check that the temperature of the refrigerator is normal (between+0^0 C and +8^0C) before you start the service.

b) Ask person in charge of the refrigerator if there have been problems with it. Inspect the logbook and temperature record sheets to see if a problem is indicated.

c) Enter into the refrigerator log books the date of your visit, and at the end of your visit write down the tasks done and measurements taken.

WHEN YOU FINISH THE SERVICE TASKS:

a) Check that the temperature of the refrigerator is normal

b) Check all components to ensure the installation is safe and secure. There should be no loss components or bare wires and the batteries should be in a secure place out of reach of children.

C.2. Cleaning the Solar Array

You should clean the surface of the solar array whenever you visit the health post.

(a) Clean the array in the early morning or in the evening when it is not in strong sunlight.

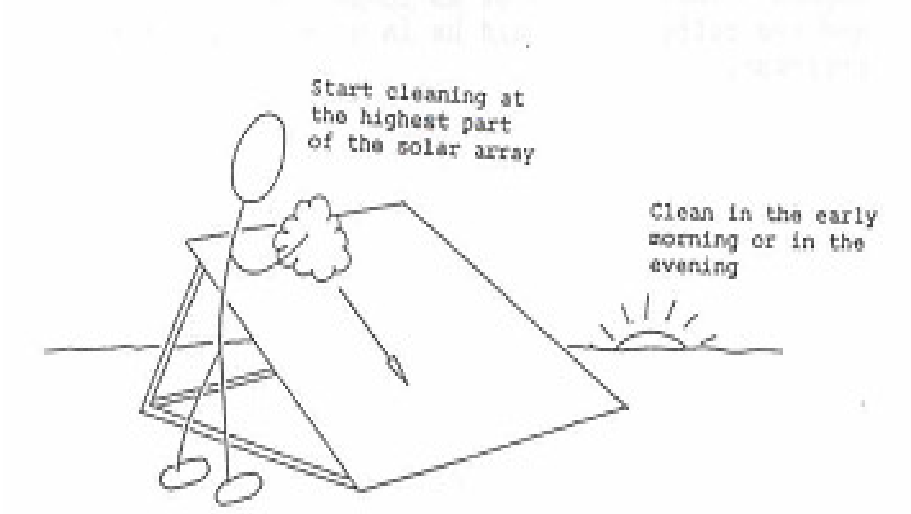
(b) If the solar array is on the roof you will need a ladder to reach it. Be very careful when working on the roof. Check that access to the array is secure and safe for the user. If not make it safe.

(c) Use a clean, soft cloth wetted with water.

(d) Wipe the surface of the solar array gently, starting at the highest point and working down to the lowest point.

(e) Do not stand on the solar array, or lean heavily on it, as this may cause damage.

(f) Make sure that the person in charge of the refrigerator knows that he/she should clean the solar array every week.



CLEANING THE SOLAR ARRAY

C.3 Preventing Solar Array Shadowing

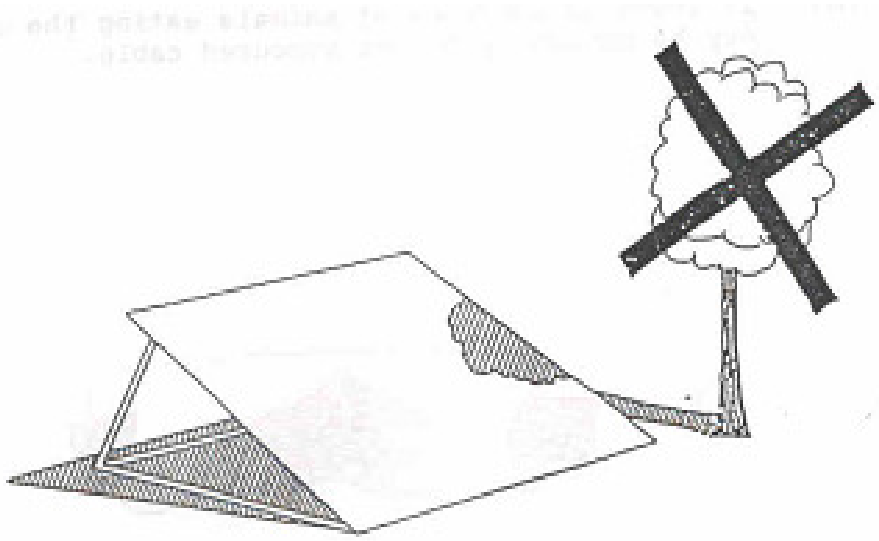
The solar array will not work properly if it is shaded during the day.

(a) Check that the solar array is not shaded on any part. This should be checked at approximately 8.00 a.m., 12.00 noon, and 4.00 p.m. on the day that you visit the health centre.

(b) Cut back bushes and trees that may start to shade the solar array between 8.00 a.m. and 4.00 p.m. Trees and bushes which cause shading only before 8.00 a.m. or after 4.00 p.m. need not to be cut down.

(c) Make sure that nobody has put anything in front of the solar array that may block the sunshine falling on it.

(d) If new building cause shadows to fall on the array it may be necessary to move the array. Consult the person in charge of the refrigerator as to where it may be moved and make arrangements to do this.



CUT BACK BUSHES AND TREES THAT MAY HAVE STARTED TO SHADE THE SOLAR ARRAY

C.4 Inspection of Electric Cables

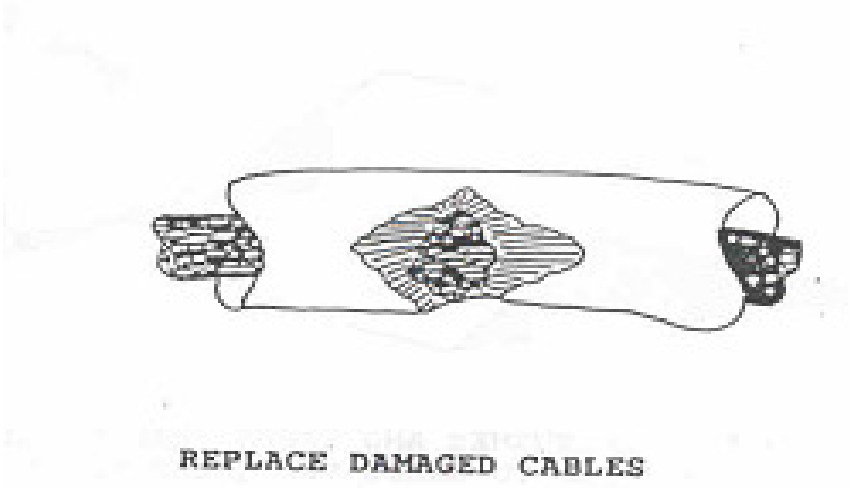
Electric cables run between the charge regulator and the solar array, the batteries, and the refrigerator. These cables should be inspected every time you visit an installation to make sure that they are in good condition.

(a) Check the connections on the cables, which go to the battery terminals, the solar array terminals, the refrigerator terminals (on the compressor controller and on the refrigerator socket), and the charges regulator terminals strip. The connections should be clean and tight. If they are loose, tighten them. If they are dirty, take them off and clean them with a wire brush before connecting them tightly.

(b) Follow each cable to its end, wherever possible. Look for the following types of damage: the cable has been cut, the insulation is worn or the insulation has been eaten away leaving the metal inside showing.

(c) If the cable is damaged, it must be replaced. Follow the instructions on page 83 to replace the cable.

(d) If there is evidence of animals eating the cables it may be necessary to use armored cable.



REPLACE DAMAGED CABLES

C.5 Checking the Performance of the Solar Array

NOTE 1: It is only necessary to check the performance of the solar array if you believe there may be problem with it. For example if the user reports or the daily record sheets indicate that the “Do not freeze Ice Packs” or “Refrigerator Disconnected” indicator lights are often lit.

NOTE 2: You should only check the solar array on a day when the sky is clear (no clouds) and at about midday.

NOTE 3: Before disconnecting any cables label them so you know where to reconnect them.

1. Clean the solar array (see page 54)
2. Check that the solar array is not shaded (see page 54)
3. Disconnect from the solar array, the array cable that leads to the charge regulator.
4. Measure the short circuit current of the solar array (see page 52)
5. Measure the open circuit voltage of the solar array (see page 51). It should be 17-20 volts for a 12-volt system.
6. Disconnect one module from the array and measure the short circuit current of the module (see page 52)

   For 12 volt systems the short circuit current in the solar array should approximately be equal to the to the current in a module multiplied by the number of modules (to within 15 %). (For example if the short circuit of one module is 2.5 Amps and there are four modules in the array then the solar array short circuit should be approximately 2.5 * 4 =10 Amps.

7. If the array current and voltage do appear correct reconnect the module and array cable.
8. If the solar array short-circuit current or open current voltage does not appear correct then there may be a fault with a module or the way the modules are connected together. Refer to faultfinding task D7 on page 58 to find out what action is required to repair the fault.

C.6 Battery Maintenance

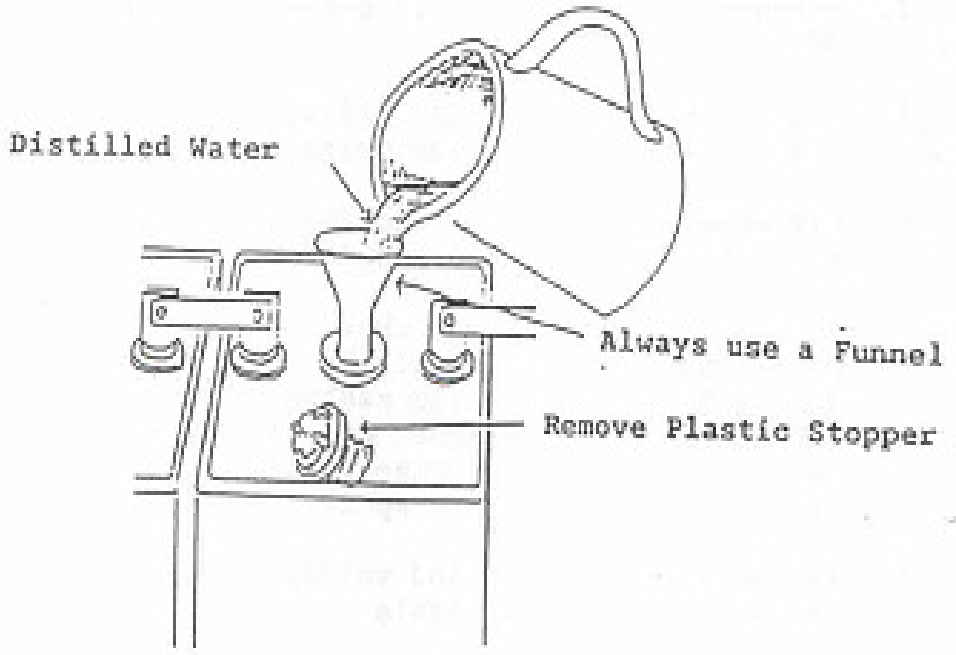
Warning:
- KEEP NAKED FLAMES AWAY FROM BATTERIES AS EXPLOSIVE GASES MAY BE PRESENT.
- THE LIQUID IN BATTERIES IS CORROSIVE. KEEP OUT OF SKIN AND AWAY FROM EYES.AVOID CONTACT WITH CLOTHES.

(a) Switch the refrigerator OFF.

(b) Disconnect the battery cables at the battery labeling the cables clearly so you know where to reconnect them.

(c) Measure, and note in the logbook, the voltage of each battery and the of the batteries combined.

(d) If the batteries are not sealed, they will have plastic stoppers in a row on the top. Remove each stopper one by one and see if the metal plates inside are covered by liquid. If the tops of the metal plates are above the liquid level, add distilled water until they are completely covered or to the level indicated in the battery. Replace the stopper. Do this for every compartment in each battery.



ADDING WATER TO THE BATTERIES

(e) If there are non-sealed batteries, measure and note in the log book the electrolyte specific gravities and temperatures and determine the state of charge of the batteries (see page no 46)

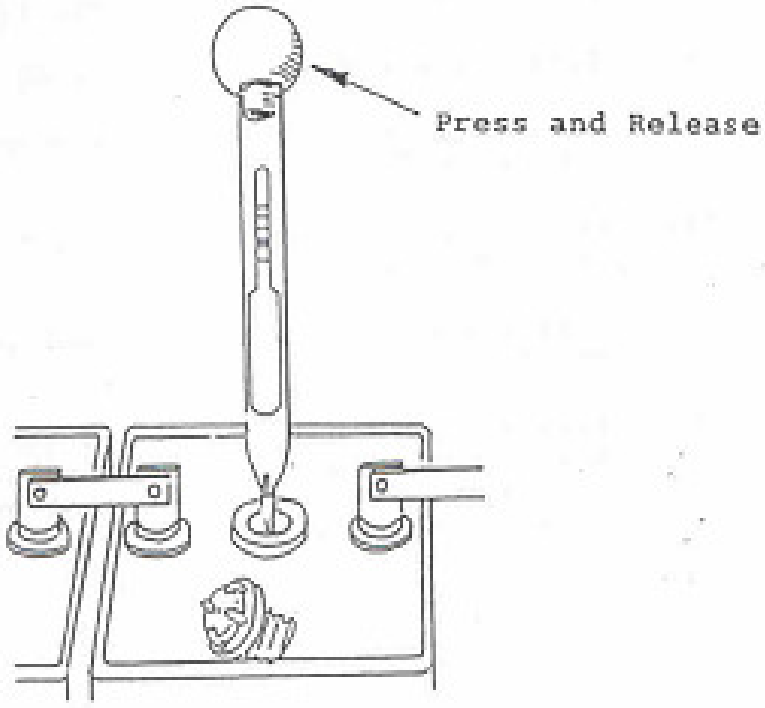
(f) Check the ages of the batteries from the logbook or from marks on them. If they are more than 5 years old, order and fit a replacement as soon as possible.

(g) Check the wiring connections to the batteries. If the wiring connections are loose, tighten them. If the connections are very dirty or corroded, loosen them and clean them with a wire brush before tightening them again.

(h) Apply petroleum greases to the terminals.

(i) Reconnect the battery cables ensuring they are in the correct position.

(j) Switch ON the refrigerator.



CHECKING THE SPECIFIC GRAVITY

C.7 Defrosting the Refrigerator

If the ice in the freezer compartment of the refrigerator is more than 5 mm (1/4 inch) thick, defrost the refrigerator.

(a) Move the vaccine into another refrigerator or store it in a cold box with ice-packs.

(b) Switch the refrigerator OFF.

(c) Open the Lid of door of the refrigerator and freezer compartment.

(d) As soon as it is possible to remove ice with your fingers, do so. Do not remove ice with knives or other sharp objects.

(e) Wipe the freezer compartment dry after all the ice has been removed.

(f) Clean the refrigerator inside with soap and water, and then dry it carefully. Never use scouring powder, steel wool or abrasive cleaners. Remember to clean the lis or door-sealing gasket and put some talcum powder on it to prevent it sticking to the lid.

(g) Switch the refrigerator back ON.

(h) Wait until the inside temperature has fallen to between 0^0Cand $+8^0$C.

(i) Put the vaccine back inside and remember to close the lid/door again.

(j) Defrosting must be carried out as quickly as possible to prevent damage to the vaccine.

(k) Tell the person in charge of the refrigerator to defrost it regularly. It should be defrosted when the ice in the freezer compartment becomes more than 5 mm (1/4 inch) thick.

C.8 Cleaning the Refrigerator

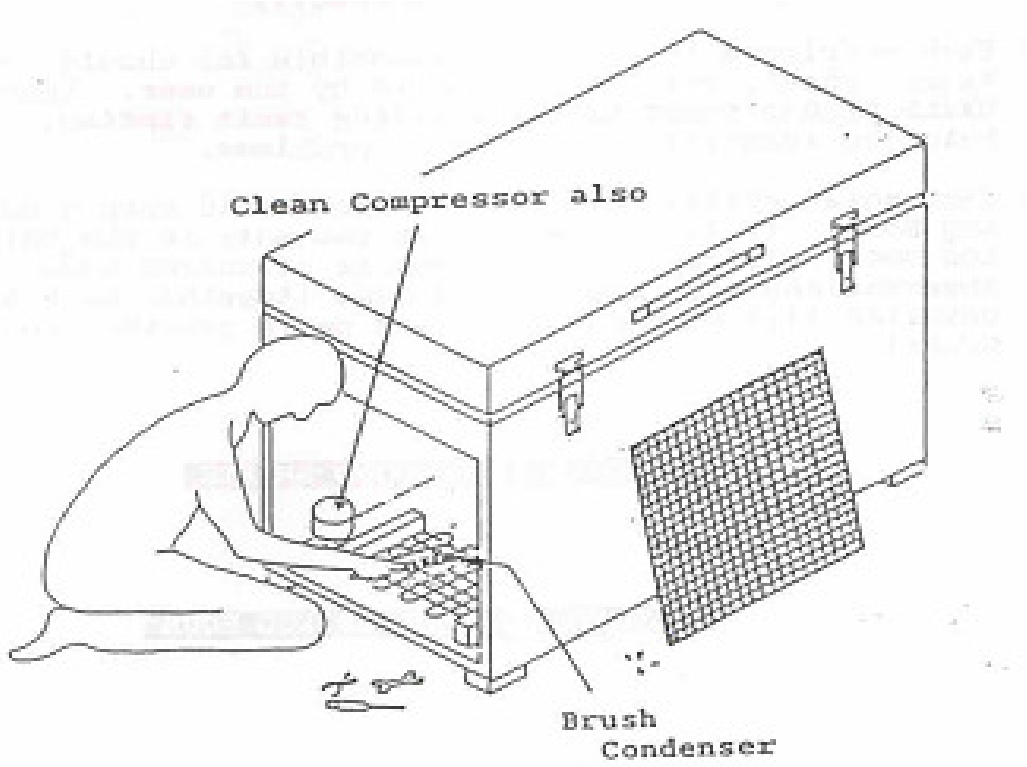
(a) Switch off the refrigerator.

(b) Clean the surfaces of the condenser and compressor using a soft brush. The condenser and compressor must be clean or the refrigerator will not work properly.

(c) If the condenser is fan-assisted make sure the fan rotates freely and brush dirt away from the fan and fan motor.

(d) Switch the refrigerator ON again.

(e) Wipe cleans the outside of the refrigerator using soap and water.



CLEAN THE CONDENSER AND COMPRESSOR

PART 3: FAULT FINDING AND REPAIR

A.1. INTRODUCTION

(a) Before starting the fault finding, make sure you are familiar with the location of the components of a solar refrigerator.

A typical solar refrigerator is layout is shown on pages 37 & 38
Annex 1 shows the location of components on the most commonly used solar refrigerator.

(b) Each installed solar refrigerator will have a USER who was trained by the installation technician on how to operate and care for the refrigerator. It is your responsibility when at a health centre to make sure that the user is operating and maintaining the refrigerator correctly.

(c) Each refrigerator you are responsible for should have a Daily Record Sheet before starting faultfinding. It may help you identify the source of problem.

(d) Each solar refrigerator technicians should keep a maintenance Log Book. It is important that you note in the maintenance log book, visits to sites, results of checks made, observations made and repairs (together with fully detailed list of parts used and parts provided to the users)

CHECK DAILY RECORD SHEETS

FILL IN MAINTENANCE LOG BOOK

B: HOW TO FIND FAULT

The instructions in this part of the handbook advise you on what to do if the refrigerator compartments are not maintaining the correct internal temperatures. The temperatures should be more than 0^0C and less than 8^0C in the refrigerator compartments, and less than 0^0C in the freezer compartment.

If the temperatures are not within these ranges you should follow this faultfinding procedure. FOLLOW THIS PROCEDURE CAREFULLY.DO NOT TRY TO TAKE SHORT CUTS. DO NOT MISS OUT ANY TASKS IN THE PROCEDURE.

B.1 Determine the Symptoms

Identify the symptoms of the fault by finding out if:

(a) The refrigerator is too warm (above 8^0C) and the compressor is NOT running. You may determine if the compressor is running by:

- Listening for the motor noise from the compressor, (but make sure that it is not the noise of the fan, if fitted),
- Touching the compressor to see if it is vibrating, and
- Touching the compressor to see if it is hot.

(b) The refrigerator is too warm (above 8^0C) and the compressor is running at times.

(c) The refrigerator is too cold.

B.2. Carry out Preliminary Checks

These preliminary checks are to be done in order to verify that the user had performed all of the user checks and tasks.

IT IS IMPORTANT that:

(a) You be sure that you have correctly identified the symptoms of the fault.

(b) You always start with the first step listed under each symptom and proceed in order through all the steps.

(c) If after doing ALL the CHECKS and ACTIONS, the refrigerator is still not working properly you move the vaccine into another refrigerator or cold box, and

(d) PERFORM THE CHECKS AND ACTIONS (LISTED ON THE NEXT PAGE) UNDER THE SYMPTOM OF THE FAULT YOU HAVE IDENTIFIED.

SYMPTOM- The refrigerator is too warm (above 8^0C) and the compressor is NOT running.

(a) Check that it is switched ON. If not, then switch it ON.
(b) Do ALL the USER maintenance checks listed on pages 65 to 67
(c) Check that someone has NOT changed the thermostat setting to a warmer setting. (Applies only if the thermostat can be adjusted). If it has, then reset it at the initial position.
(d) Check that the fuse has not blown. If it has, replace it. If the fuse blows for a second time proceed step by step through the Fault Finding Chart on page no 41.

SYMPTOM- The refrigerator is too warm (above 8^0C) and the compressor is running at times.

(a) Do ALL the USER maintenance checks listed on pages 65 to 67

(b) Check that someone has NOT changed the thermostat setting to a warmer setting. (Applies only if the thermostat can be adjusted). If it has, then reset it at the initial position.

(c) If the refrigerator compartment temperature is still more than 8^0C,proceed step by step through the Fault Finding chart on page 63

SYMPTOM- The refrigerator is too cold:

REMEMBER VACCINE IS DESTROYED IF FROZEN.

(a) Some refrigerators have a movable separator between the freezer compartment and the refrigerator compartment. If it has been removed incorrectly positioned, or is partly broken, replace it or repair it.

(b) Check that someone has not changed the thermostat setting to a colder setting. (Applies only if the thermostat can be adjusted). Reset it at the initial position and wait for the temperature in the refrigerator compartment to warm up. (This may take some time).

(c) If the refrigerator compartment temperature is still less than 0^0C.proceed to the Fault finding Chart on page64.

C: FAULT FINDING CHART

CHART NO.1

SYMPTOM - Refrigerator is too WARM and compressor is NOT running.

Check out the following possible faults by first looking at the fault at the top of the chart. If this is found not to be the fault then move to the next fault in the direction of the arrows.

Possible fault	Fault finding & Repair Task No.	Page no
Switched OFF	**Switched ON**	
User maintenance task	**D.1.**	**65**
Thermostat	**D.2.**	**67**
Fuse in compressor controller	**D.3.**	**69**
Fuse in charge Regulator	**D.4.**	**71**
Low state of charge of battery	**D.5.**	**72**
Wiring	**D.6.**	**75**
Solar Photovoltaic Array	**D.7.**	**75**
Compressor controller	**D.8.**	**76**
Charge Regulator	**D.9.**	**77**
Compressor	**D.12.**	**79**

CHART NO. 2

SYMPTOM-Refrigerator is TOO WARM (above 8^0C) and the compressor is running at times.

Check out the following possible faults by first looking at the fault at the top of the chart. If this is found not to be the fault then move to the next fault in the direction of the arrows.

Possible fault	Fault finding & Repair Task No.	Page no
User Maintenance Task	**D.1.**	
Thermostat	**D.2.**	
Low State of Charge of Battery	**D.5.**	
Wiring	**D.6.**	
Solar Photovoltaic Array	**D.7.**	
Condenser Fan (when fitted)	**D.10**	
Charge Regulator	**D. 9.**	
Cooling Circuit	**D.11**	
Compressor	**D.12.**	
System Sizing	**D.13.**	

CHART NO. 3

SYMPTOM-Refrigerator is TOO COLD

Remember –VACCINE IS DESTROYED IF FROZEN

Check for the following possible faults by first looking at the top of the chart. If this is found not to be the fault then move to the next fault in the direction of the arrows.

Possible fault	Fault finding & Repair task No.	Page no
Movable Separator Between refrigerator and Freezer damaged, incorrectly Positioned or removed. (Applies only to some types Of refrigerator cabinets, E.g. Electrolux RCW 42)	replace or repair seperator	
↓		
'Continuous running'," draw down" Or "freezer" switches on. (Applies only to some types Of refrigerator with these additional switches)	Switch the Refrigerator back on to normal mode.	
↓		
Thermostat faulty	D.2.1	67

D FAULT FINDING AND REPAIR TASKS DESCRIPTIONS

D.1. USER MAINTENANCE TASKS

The user is responsible for undertaking routine maintenance tasks. If the refrigerator stops operating correctly, the user is also trained to do simple checks before calling for the solar refrigerator technician.

IT IS YOUR RESPONSIBILITY TO:

● MAKE SURE THAT THE USER HAS DONE ALL OF HIS MAINTENANCE TASKS CORRECTLY, AND THE SIMPLE FAULT FINDING CHECKS BY RE-DOING THE SAME TASKS, AND

● TRAIN THE USER IF ALL TASKS ARE NOT DONE CORRECTLY.

Technician Action required

(a) Check that the DAILY RECORD SHEETS of the user are filed in correctly. Check:

● the refrigerator temperature record. The refrigerator should ALWAYS been operating above 0^0C.

● if there is a record of warning indicator light being lit. The warning indicator lights are normally labeled as “Do not Freeze Ice Packs” and “Low Battery State of Charge” or “Refrigerator Disconnected”.

(b) Check that the refrigerator is switched ON, if not, turn it ON.

(c) Check that no obstacles are preventing free air circulation around the refrigerator.

(d) Check that the ice formation on the evaporator is less than 5 mm thick. If it is more, defrost the refrigerator.

(e) Find out from the User if defrosting is often necessary, if he says ‘Yes’ then check the lid of door sealing gasket. If the seal is not making good contact, either:

● glue it back on,

● replace the seal, and/or

● adjust the door.

If it is necessary to replace the seal or adjust the door, check afterwards that the contact between the lid/door and the refrigerator cabinet is good.

(f) Check that:

● The condenser and compressor are free from dust.

● that the fan (if fitted) turns freely, and

● that the outside of the refrigerator cabinet is clean.
If not clean them thoroughly.

(g) Check that the solar array is clean and that a clean cloth is available to clean the array.

(h) Check that the solar array is not shaded or even partly shaded from trees or other obstructions from at least 8.00 a.m. in the morning until 4.00 p.m. in the afternoon. If it is shaded, cut back the trees or remove the obstacle. If neither is possible it will be necessary for an installation technician to move the solar array to another place where it is not shaded.

(I) Check the condition of the batteries:

1) Check the level of electrolyte (acid and water mixture) in each battery cell if the battery is not sealed type. The metal plate MUST be well covered.

2) Add clean distilled water to the batteries if the metal plates are not covered. Follow the procedure explained on page 57.

3) Ask the user:

● If he has added distilled water

● in which cells he added water

● When was the last time he added water

● how often he adds water, and to which cells.

● if the level of water in any cell has ever dropped below the op of the metal plates.

● where he obtains his distilled water, and how often.

● what the distilled water is stored in, and how is the container closed.

This information will help you determine if the batteries are in good condition. Since:

● if a cell in a battery needs water added more often than the other cells, then this cell is no longer operating correctly and the battery should be replaced.

● if a battery needs water often (more than once in six months) then it is either poorly ventilated exposed to direct sunlight, or is being deeply discharged in which case its life will be considerably shortened.

● if a water added to a battery is not clean and distilled; the battery life will be shortened.

● if the plates of the battery are exposed to the air, then they are damaged and the battery should be replaced.

(j) If you have DONE ALL of the above user Maintenance Tasks and have not found anything which would cause the refrigerator not to operate correctly, then PROCEED TO TEE NEXT STEP ON THE FAULT FINDING CHART.

D.2. FAULTY THERMOSTAT

2.1 REFRIGERATOR IS TOO COLD (COLDER THAN 0^0C)

SYMPTOMS OF THE FAULT
1. The refrigerator compartment is too cold.
2. The compressor MAY run all the times

HOW TO CONFIRM THIS FAULT

1.Check the evaporator is adequately defrosted.

2. Check the thermostat-sensing element is firmly attached. (In some refrigerator it is attached to the evaporator)

3. Adjust the thermostat to its warmest position.

4. If the refrigerator compressor continues to run, the thermostat is faulty. See below for action required.

5.If the compressor stops running, adjust the thermostat until the temperature in the refrigerator compartment is above 0^0Cand below 8^0C.see page 83 for how to adjust the thermostat.

Action required

1. Remove ALL vaccine to another refrigerator or cold box with ice packs.

2. If the compressor continues to run when the thermostat is adjusted to any position, CHANGE THE THERMOSTAT IN ACCORDANCE with the manufacturers instructions.

3. Reload the refrigerator.

2.2 REFRIGERATOR TOO WARM (Warmer than 8^0C)

SYMPTOMS OF THE FAULT

1.The refrigerator compartment is too warm.

2.the compressor MAY not be running or running
Only very occasionally

Hoe to confirm this fault

1. Check the evaporator is adequately defrosted. If it is not this may be the problem. Defrost the refrigerator.

2. Check that the “Do Not Freeze Ice Packs” or “Refrigerator Disconnected” indicator lights are not lit. If they are lit the problem is not the thermostat, so proceed to the next step in the faultfinding chart.

3. Check the thermostat wires are tightly connected to terminals T and C of the compressor controller. If tightening the connection causes the compressor to run the fault has been repaired.

4. Check the thermostat wires are tightly connected to the thermostat unit (Mechanical type only). If tightening the connection causes the compressor to run the fault has been repaired.

5. Check the wires from the thermostat unit to the compressor controller for signs of damage. If damage is apparent replace the wire.

6.Adjust the thermostat to its coldest position.

7.If the compressor now runs the thermostat setting was incorrect. Adjust the thermostat to obtain 2^0C to 4^0C in the bottom of the refrigerator compartment as explained on page 83.

8. If the compressor still does not run connect a wire across the 2 terminals of the thermostat.

9. If the compressor runs when you connect the temporary wire, but do not run with this temporary wire then:

- The thermostat is faulty or

- The wires are incorrectly connected or

- The wires are defective

Repair Action required

1.Tighten, correct or change the wires.

2. If the compressor still does not run CHANGE THE THERMOSTAT in accordance with the manufacturers instructions.

D.3. FUSE BLOWN IN COMPRESSOR CONTROLLER

SYMPTOMS OF THE FAULT

1.The refrigerator is TOO warm AND THE COMPRESSOR IS NOT RUNNING

2.REFRIGERATION DISCONNECTED indicator light may be lit.

How to confirm this fault

1.Switch off the regulator.

2.Remove fuse from the compressor controller. Check that the fuse holder is not corroded and that the fuse fits tightly in the fuse holder.

3. Check the electrical resistance of the fuse.

4. Thoroughly clean the fuse holder.

5.Replace the fuse with a spare fuse that has been checked to be good.

6.Switch the refrigerator on. (Some models also have a circuit breaker protecting the refrigerator, make sure that it is also switched ON.) If the compressor now runs, the fault is confirmed and has been replaced.

7.If the compressor does not run check the fuse again. If it has blown against do the actions listed below.

Repair action require

1.Check that you spare fuse is of the correct type and correct rating.

2.Check that the batteries are of the correct voltage and are connected together correctly.

3.heck that the connections between the batteries and the compressor controller are correct and tight. (Positive wires connected to the positive terminal of the compressor controller and negative to the negative terminal).

4. Switch OFF the refrigerator.

5 Disconnect at the compressor controller the wires from the thermostat and fan (if fitted). Fit a temporary wire between terminals T and C of the compressor controller.

6.Replace the fuse with a good fuse of the correct type and switch on the refrigerator.

7. If the refrigerator runs there is fault in the thermostat or fan, which is causing the fuse to blow, when they are connected. Connect each one separately to determine which is faulty-the thermostat or the fan.

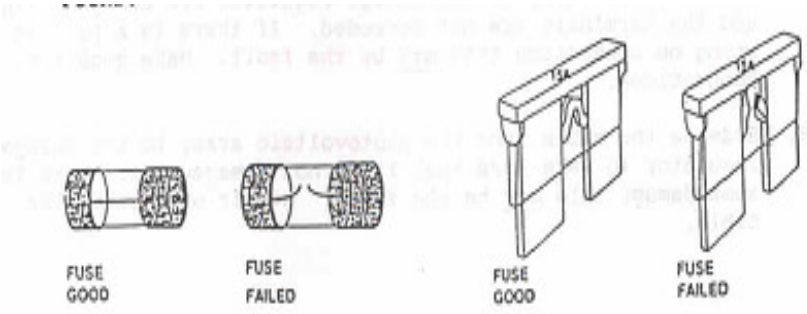
8. If the fuse blows again, switch OFF the refrigerator, remove the electrical socket from the compressor. (This disconnects the compressor controller from the compressor), fit a new fuse, and switch on the refrigerator.

9.If the fuse does not blows with the compressor socket disconnected, the fault is probably in the compressor. Proceed with the next steps in the faultfinding Chart to make sure of your diagnosis before replacing the compressor.

10. If the fuse blows each time you replace it and switch on the fridge with and without the compressor socket disconnected, then change the compressor controller (see page 85)

11. Fit a new fuse and switch ON the refrigerator again. If with the new compressor controller the fuse does not blow the fault was the compressor controller. If the fuse continues to blow, PROCEED TO THE NEXT STEP ON FAULT FINDING CHART no.1

DO NOT FORGET TO REPLACE THE FUSE LATER WHEN THE FAULT IS FOUND.



D4.FUSE BLOWN IN CHARGE REGULATION

SYMPTOMS OF THE FAULT

The refrigerator is TOO WARM and the compressor is not running.

HOW TO CONFIRM THIS FAULT

SOME TYPES OF CHARGE REGULATOR DO NOT HAVE FUSES in the charge regulator, if this is the case then proceed to the next step on FAULT FINDING CHART no.1

If the charge regulator is fitted with a fuse then

1.Switch off the refrigerator

2. Remove the fuse from the charge regulator. Check that the fuse holder is not corroded and that the fuse fits tightly in the fuse holder.

3. Check the electrical resistance of the fuse.
If the fuse has blown take the action detailed below. If the fuse has not blown replace the fuse and proceed with the next step on the FAULT FINDING CHART NO.1

Repair action require

1Check that you have the correct fuse.

2.Check that the positive and negative connections from the photovoltaic array to the charge regulator are correct, tight and terminals are not corroded. If there is a poor or wrong on connection this may be the fault. Make good the connections.

3. Examine the cable from the photovoltaic array to the charge regulator to make sure that it is not damaged. If there is some damage this may be the fault. Repair or replace the cable.

4. Check that the batteries are connected with the correct polarity to the charge regulator and that any other connections are correct, tight and not corroded.

5.Fit a fuse tested to be good and of the correct size.

6. Switch on the refrigerator. (Some models also have circuit breaker protecting the refrigerator, make sure that it is also switched on.)

7.Turn off the refrigerator, take out the fuse and check it.
If the fuse is:

- Blown then PROCEED TO THE NEXT STEP ON THE FAULT FINDING CHART to find out why the fuse is blowing.

DO NOT FORGET TO REPLACE THE FUSE LATER

- Not blown, also PROCEED TO THE NEXT STEP ON THE FAULT FINDING CHART. This is because the original fuse must have blown for a reason, and you have to find the reason.

D5: LOW STATE OF CHARGE OF BATTERIES

THE BATTERIES MAY BE FAULTY OR MAY ONLY HAVE A LOW STATE OF CHARGE as a result of a long period of cloddy weather.

SYMPTOMS OF THE FAULT

1 The refrigerator is too warm.

2 The voltmeter (not fitted to all models) shows battery voltage to be less than 11.5 V.

3.THE REFRIGERATOR DISCONNECTED indicator light is lit of has lit recently.

How to confirm fault

1.Cover the solar array so that NO sunlight falls on it.

2.Check that the refrigerator is switched ON.

3.measure the voltage of the batteries at the + and – terminals of the compressor controller.

- The voltage should be greater than 11.5 volts for 12-volt systems (22.6 volts for 24 volt systems) if the compressor is NOT running.

- The voltage should be greater than 10.5 volts for 12 volts systems (21.3 volts for 24 volt systems) if the compressor IS running.

4. If the voltage at the compressor controller terminals is not greater than the values shown above, the batteries have a low state of charge.

Repair action required

1. Switch off the regulator.

2. If you have a fully charged replacement battery available (2 batteries for 24 volt system) remove the battery from the refrigerator and connect the fully charged battery.

3. With the solar array still covered, switch ON the refrigerator. THE REFRIGERATOR COMPRESSOR SHOULD NOW RUN.

4. If the COMPRESSOR DOES NOT RUN PROCEED TO THE NEXT STEP ON THE FAULT FINDING CHART.

5. If the COMPRESSOR DOES NOT RUN:

(a) Check the level of distilled water in each cell of each battery, and top up the water if necessary (see page 57)

(b) Recharge each battery (unless battery manufacturer or supplier states this is not to be done for your batteries)

6. Recharge the batteries by switching OFF the refrigerator and:

(a) Allowing five days for the batteries to be recharged by the solar array, OR

(b) By removing the batteries from the refrigerator and charging with a battery charger.

(c) When fully charged by either method, disconnect each battery and leave each battery for 2 hours.

(d) Connect the battery (2 batteries for 24 volts system) to the refrigerator, switch in the refrigerator and measure the voltage between the + and – terminals of the compressor controller.

(e) If the voltage of the battery with the compressor running is LESS THAN 12.5 volts (or 25 volts for 24 volt system), the battery is not holding the charge and should be replaced (see page 87)

(f) Repeat step (d) for each of the batteries you have charged.

(g) Reconnect the correct number of batteries required for the solar refrigerator.

(h) If NO batteries need replacing, PROCEED TO THE NEXT step on the FAULT FINDING CHART, which corresponds with the symptom you, have diagnosed. This will enable you to find out if the low state of charge of your batteries is the result of other fault in your system.

D6. WIRING

SYMPTOMS OF THE FAULT

1. The refrigerator is too warm and the compressor is not running.

2.The refrigerator operates normally sometimes but at other times the refrigerator Is too warm and the compressor is not running.

How to confirm this fault

1. Check the voltage at:

   (a) The terminals of the charge regulator WHICH ARE CONNECTED TO THE SOLAR ARRAY CABLE. In sunlight this voltage should be 13.5 to 19 volts. (27 to 38 volts for 24-volt system)

   (b) The + and – terminals of the compressor controller, the voltage should be 11.5 to 13 volts if the batteries are adequately charged. (23 to 26 volts for 24-volt system)

2. If the voltage at the charge regulator and the compressor controller do not corresponds with the above values, then there may be wiring fault. See below for what action you should take.

Repair action required

1. Switch OFF the refrigerator.

2.Label wires before disconnecting them so that you know where to reconnect them.

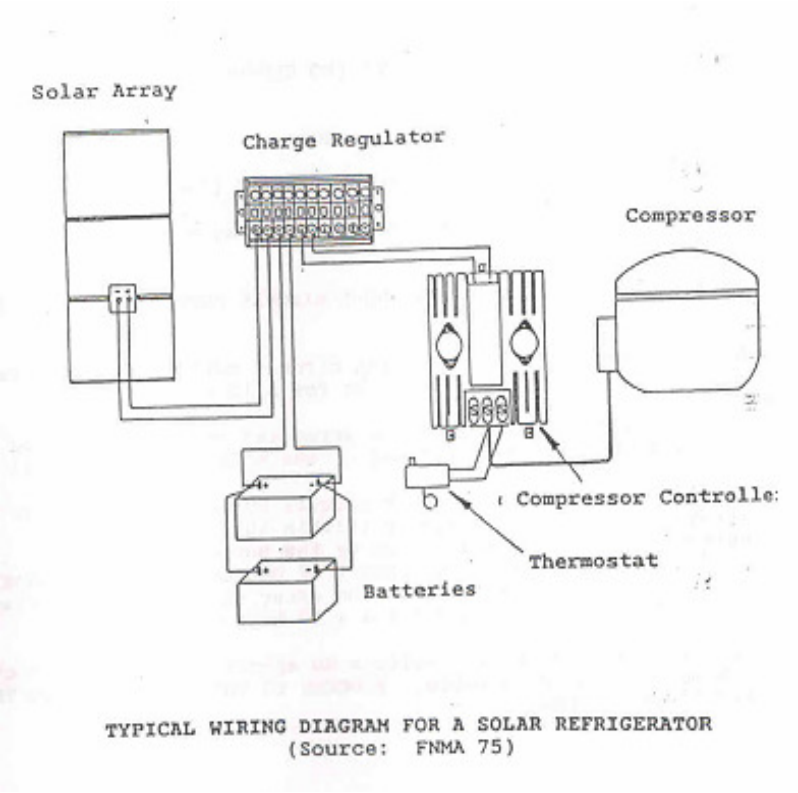
3. Inspect all the electrical cables and connections. Repair or replace any, which are visibly defective.

4. Disconnect the solar array wires from the charge regulator.

5.Clean all terminals of the charge regulator and solar array junction box.

6. Check the voltage at the charge regulator and compressor controller again as detailed above under" How to confirm this fault."

If the voltages are now correct the faults has been repaired.
If the voltage is still not correct PROCEED WITH THE NEXT CHECK ON THE FAULT FINDING CHART.



TYPICAL WIRING DIAGRAM FOR A SOLAR REFRIGERATOR
(Source: FNMA 75)

D.7 PHOTOVOLTAIC ARRAY

SYMPTOMS OF THE FAULT

1. The refrigerator is too warm and the compressor is not running or is running only very occasionally.

2. The Batteries become discharge periodically.

3. The indicator lights for normal operations my not be lit or the “Refrigerator Disconnected” and “Do not Freeze Ice Packs” lights are often lit.

How to confirm this fault

ON A DAY WHEN THE SKY IS CLEAR (NO CLOUDS) AND AT ABOUT MIDDAY;

1.Clean the solar array (see page 54)

2. Check that the solar array is not shaded (see page 54)

3.Disconnect from the solar array, the array cable that leads to the charge regulator.

4. Measure and write down the short circuit current of the solar array (see page 52)

5.Measure and write down the open circuit voltage of the solar array .It should be 17-20 volts for a 12-volt system.

6. Disconnect one module from the array and measure and write down the short circuit current of the module (see page 52)

For 12-volt systems the short circuit current in the solar array should be approximately (within 15%)equal to the current in a module multiplied by the number of modules. (For example if the short circuit of one module is 2.5 Amps and there are four modules in the array then the solar array short circuit should be 2.5 * 4 = 10 Amps).

7. If the array current and voltage do appear correct reconnect the module and array cable. PROCEED TO THE NEXT CHECK IN THE FAULT FINDING CHART.

8.If the solar array short circuit current or open current voltage does not appear correct then there may be a fault with a module or the way the modules are connected together.

9.Measure the open circuit voltage and short circuit current in each module with each module disconnected from the other modules.

10.If the voltage and current measured on one module is not similar, to other modules (more than 15% different) the module is probably faulty and should be replaced.

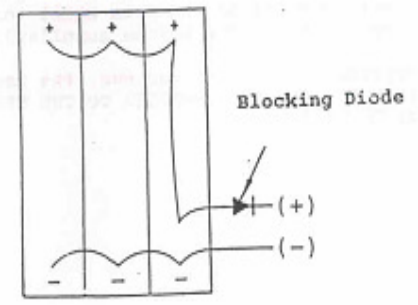
11. If the voltage and current of all the modules are similar then there was probably a poor connection on one module or faulty wire.

Repair action required

1.If a module is faulty (replace it as described on page 82)

2.If a wiring fault or connection fault between modules is suspected check the electrical continuity of each wire and clean all the wire terminals.

3.Reconnect all the modules to the array and check all connections are correct. Typical wiring for 1 12-volt system is shown below.



4. Check the output of the solar array again to confirm that the correct array current is approximately equal to the current of one module times the number of modules and hence is correctly connected.

D.8 COMPRESSOR CONTROLLER

SYMPTOMS OF THE FAULT

The refrigerator is too warm and the compressor does not run

How to Confirm this fault

Measure the voltage at the input terminals of the compressor controller. If the voltage is more than 11.5 volts (12 volt system) or more than 22.5 volts (24 volts system) the compressor should run. If the compressor does not run, proceed as follows.

Repair action required

1. Remove the thermostat and compressor fan wires (if fitted). From terminals T, C, and F of the compressor controller. Fit a temporary wire between terminals T and C. The compressor should then run.

2. If the compressor does not run, CHECK THE FUSE, in the compressor controller again as explained on page no 69.

3. If the compressor still does not run, change the compressor controller with another of the same model (or compressor controller specified by the system supplier) see page 85.

4. If the compressor still does not run, the compressor controller is NOT FAULTY.PROCEED TO THE NEXT STEP ON THE FAULT FINDING CHART No.1

D.9 CHARGE REFULATOR FAULTY

SYMPTOMS OF THE FAULT

1. The refrigerator is too warm and the compressor is not running only occasionally.

2.The batteries become discharged periodically.

How to confirm this fault

1. If all previous steps in the faultfinding procedures have not indicated a fault then change the charge regulator (see page 84) and see if the refrigerator operates normally for at least one month.

Repair Action required

1. If after replacing the charge regulator the solar refrigerator works correctly for one month the fault was probably the Charge Regulator.

D.10 CONDENSER FAN (If fitted)

SYMPTOMS OF THE FAULT

The refrigerator is too warm and the compressor is a not run very frequently.

How to confirm this fault

When the compressor is running look to see if the condenser fan is rotating.
If it is rotating this is not the problem. Proceed to the next check in the faultfinding chart.
If it is not rotating a fault if indicated, see below for the action you should take.

Repair action required

1. Switch off the regulator.

2. Disconnect the fan wires from the compressor controller. Check the continuity of each wire. If a break in a wire is detected replace the wire.

3. Clean the connections and reconnect the fan wires to the compressor controller.

4.Check to see if the fan can freely rotate. If it is jammed remove the item that is stopping it from rotating.

5.Switch ON the refrigerator.

6. If the fan now rotates when the compressor is running the fault has been repaired.

7.If the fan still does not rotate replace the fan as described on page 86.

D.11. COOLING CIRCUIT FAULT

SYMPTOMS OF THE FAULT

The refrigerator is too warm and the compressor is a not run continuously or very frequently.

How to confirm this fault

1. If the compressor runs and the evaporator plate do not get cold all over then:

(a) The cooling circuit may be undercharged with refrigerant, or

(b) The capillary tube blocked, or

(c) There may be moisture in the system

2. If the refrigerator is correctly charged with refrigerant, there must be liquid in the pipe coming out of the condenser. To check this, do the following:

(a) Adjust the thermostat to its coldest setting and run the compressor for at least five minutes.

(b) With the compressor running, hold a lighted match under the condenser outlet pipe until the match is finished.

(c) As soon as the match has gone out put your finger on the pipe here the match heater it.

(d) The pipe should be warm only. The liquid in the pipe will absorb if there is liquid inside the pipe the heat form the match. If the pipe is too hot for you to keep your fingers on it, then there is no liquid in the pipe. These mean that the refrigerator is not adequately charged with refrigerant.

Repair action required

IF YOU ARE SURE THAT the symptoms indicate that there is insufficient refrigerant in the refrigerator or there may be problem with moisture or a blockage, then REFER TO THE TECHNICIANS HANDBOOK FOR COMPRESSION REFRIGERATORS, PART B, FAULTS AND FAULTS FINDING. Page 7 gives a faultfinding chart and procedure to find and replace the fault.

D.12 COMPRESSOR

SYMPTOMS OF THE FAULT

The refrigerator is too warm.

How to confirm this fault

1. Measure the Voltage at the input terminals of the compressor controller. If the voltage is more than 11.5 volts (12 volt system) or more than 22.5 volts (24 volts system), the compressor should run.

2. If the compressor runs continuously and the refrigerator temperature does not decrease to less than 8^0C after 4 hours, a cooling circuit problem is evident go to page 77.

3. If the compressor does not run, proceed as follows.

4. Switch OFF the refrigerator and disconnect the electrical socket from the compressor.

5.Measure the electrical RESISTANCE between the following connections on the compressor plug with your OHMMETER :(see diagram on Pins on next page)

- Pins No. 1 and 3.

- Pins No. 4 and 3.

- Pins No. 2 and 3.

The electrical RESISTANCE should be VARY LOW between these connections.

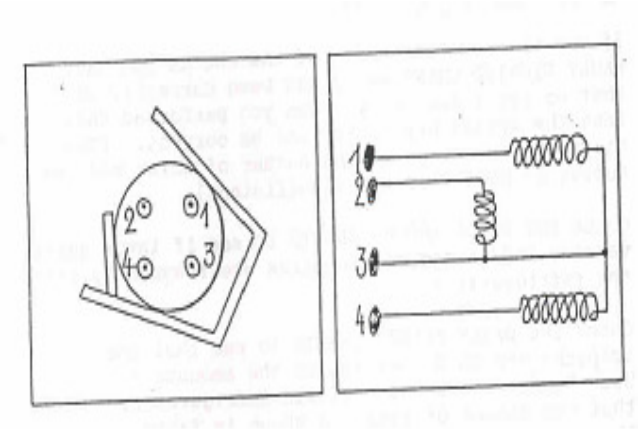
6.Measur the electrical RESISTANCE between Pin No. 3 and the metal body of the compressor. Make sure that you have good electrical contact between your OHMMETER lead and the compressor metal body. The electrical RESISTANCE should be VERY HIGH.

7. If the electrical RESISTANCE between the compressor pins (see Para .5.above) is not VERY LOW and the electrical RESISTANCE between pin No.3 and the compressor body is NOT VERY HIGH, then the compressor is faulty.

Repair action required

1. ONLY CHANGE COMPRESSOR WHEN YOU ARE SURE THAT ALL PREVIOUS STEPS IN THE FINDING CHART HAVE BEEN CAREFULLY CHECKED.

2. Replace the compressor in accordance with the manufacturers instructions, Refer also to the procedure described in the WHO handbook for COMPRESSION refrigerator repairs. (Refer to the inside of the front cover of this handbook for details.)



D.13 SYSTEM SIZING

SYMPTOMS OF THE FAULT

1. Refrigerator operates correctly during certain seasons, but the battery becomes discharged at times in the year when it is not very sunny or the ambient temperature is high.

2. The indicator light “Do NOT Freeze Icepacks” and possibly “Refrigerator Disconnected” are lit early in the morning especially at the times in the year when it is not very sunny or the ambient temperature is high.

How to confirm this fault

1. If you are sure that each of the checks you have made in FAULT FINDING CHART NO.2 has been correctly performed and that no fault was found, when you performed these checks, then the system sizing may not be correct. (The system sizing is incorrect if numbers of solar modules and/or the number of batteries are insufficient.

2.Check the DAILY RECORD SHEETS to see if large quantities of vaccine and /or medical supplies are frequently loaded into the refrigerator.

3. Check the DAILY RECORD SHEETS to see that the quantities of icepacks frozen do not exceed the amounts recommended in the USER HANDBOOK for photovoltaic refrigerator, Table 1, and that the amount of icepacks shown in Table 1 is not more than the quantity specified for this type of refrigerator system.

4.Check with the person who is responsible for the refrigerator to make sure that the food and drinks and other non-medical supplies are not being kept in the refrigerator and that items other than icepacks are not being frozen in the freezer compartment.

5. If the above checks indicate that the refrigerator is being correctly operated and that no parts of the system are defective, then closely observe the operation of the refrigerator during several days and note when the indicator lights shows “Do Not Freeze Icepacks” and possibly “Refrigerator Disconnected”.

6. If the problem continues a part of the system may be undersized.

Repair action required

1.Write down your findings on the DAILY RECORD SHEETS kept by the user:

2. Prepare a note with a full explanation of checks performed and your conclusions that there may be a problem with sizing.

3. Send or preferably hand-deliver your note to:

(a) The chief of the solar refrigerator installation team.

(b) The person responsible for solar refrigerator in the organization responsible for the EPI program in your country.

(c) Ask your head of department to send a copy of your note to the Cold Chain Unit. Expanded programme on Immunization at the World Health Organisation, 1211 Geneva-27, Switzerland.

4. Advise the user that he or she should refrigerate only vaccine and other essential items and should try to minimize the number of unfrozen ice packs placed in the freezer at one time.

REMEMBER: VACCINE AND ESSENTIAL MEDICAL ITEMS ONLY SHOULD BE IN THE REFRIGERATOR

E. REPAIR TECHNIQUES

E.1 INTRODUCTION

Some of the repair tasks that you may have to carry out on the cooling system of a solar powered refrigerator are similar to those for a normal compression refrigerator. These have been fully described in the Technicians Handbook for compression refrigerators Parts A, B and C, produced by WHO Expanded Programme on Immunization. You should have a copy of each of these three booklets in order to carry out the repair tasks listed below.

(a) Replacing a thermostat (see part C)

(b) Replacing a compressor ((see part C)

(c) Mending a refrigerant leak (see part A & part C)

(d) Recharging the refrigerant loop when the system is undercharged (see part A & part B)

(e) Recharging the refrigerant loop when the system is overcharged (see part B)

(f) Replacing the evaporator (see part C)

(g) Replacing a capillary tube (see part C)

(h) Replacing a fitter/drier (see part C)

(i) Replacing the lid /door sealing gasket

(j) Adjusting the lid/door sealing

(k) Adjusting dropped or twisted doors.

Other repair tasks that you may have to carry out on a solar powered refrigerator are described in the following pages.

You should also always refer to the maintenance and repair handbook of the solar refrigerator manufacturer, if these are available as their instructions should be more specific.

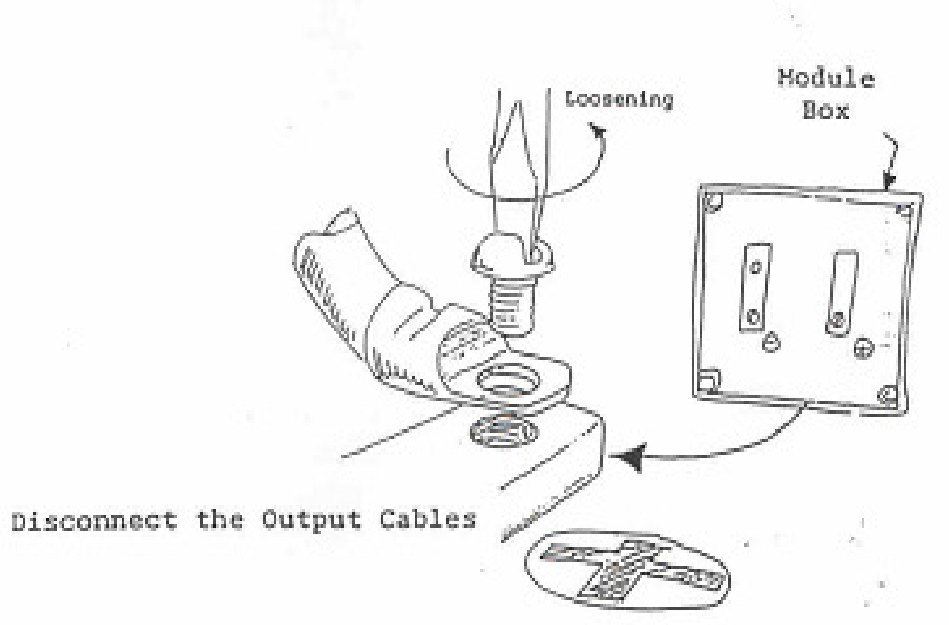
E.2 REPLACING A MODULE OF THE SOLAR ARRAY

(a) Work on the solar array early in the morning or in the evening. Completely cover the front of the solar array with thick cloth or a sheet. The solar array must <u>not</u> be in bright sunshine when you work on it except when you are checking performance.

(b) Disconnect the wires from the solar array at the charge regulator terminal strip. Use insulated tools and is careful not to touch the terminals with your hands as you get an electric shock.

(c) Remove the lid of the junction box at the back of the faulty module.

(d) Mark the positive wire and the negative wire. Then disconnect the module output cables from the positive and negative terminals in the terminal box.



(e) Loosen the mounting bolts from the module and remove the module from the solar array frame.

(f) Place the new module (which has been checked to be of the correct type and good performance) in the solar array frame and tighten the mounting bolts.

(g) Connect the module cables to the correct terminals in the module terminal box.

(h) Replace the lid of the module terminal box. Do not over tighten the lid screws.

(i) Reconnect the solar array back to the charge regulator at the charge regulator terminal strip. Be careful not to touch the terminals with your hands.

(j) Remove the cover or sheet from the solar array

(k) Check the performance of the solar array (see page 56)

E.3 ADJUSTING THE THERMOSTAT

(a) Set the thermostat in its middle position (halfway between its maximum and minimum settings). Allow 4 hours for the temperature to stabilize.

(b) Read the thermostat in the bottom of the refrigerator compartment after 4 hours. The temperature should be 2^0C and 4^0C.

(c) If it is not, adjust the thermostat to a warmer or colder setting as appropriate. Allow another 4 hours before checking the temperature.

(d) Continue adjusting and checking in the same way until the temperature in the bottom of the refrigerator compartment is between 2^0C and 4^0C.

REMMBER: WAIT 4 HOURS BETWEEN ADJUSTING THE THERMOSTAT AND CHECKING THE TEMPERATURE.

E.4. REPLACING POWER CABLES

(a) The power cables are electrical wires running from the charge regulator to the solar array, the batteries and the refrigerator.

(b) If one of these cables is damaged it must be replaced because it might cause a short-circuit. Do not mend the damaged cable, except as a temporary measure.

(c) Turn the refrigerator OFF.

(d) Cover the solar array with a thick cloth or sheet.

(e) Disconnect the damaged cable from its terminals. If the cable is between the battery and the charge regulator, disconnect the battery terminals first. If the cable is between the solar array and the charge regulator, disconnect the solar array terminal first. If the cable is between the refrigerator and the charge regulator, disconnect the charge regulator first .Use insulated tools and do not touch the terminals with your hands to avoid any risk of electric shock.

(f) Replace the damaged cable with a new one.

(g) Remove the cover placed over the solar array.

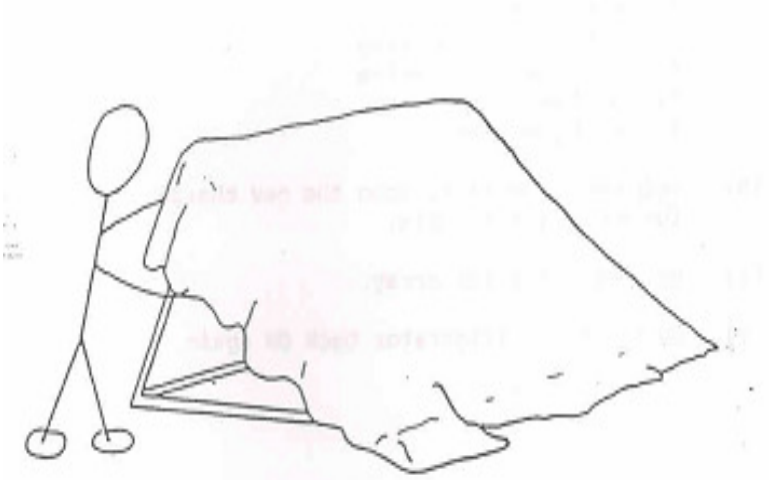
(h) Turn the refrigerator back on.

(I) After replacing the damaged cable consider what may have caused it to be damaged. If there is nearby sharp edge causing" freeting" smooth it off. If rodents or termites are the problem take the necessary action to be rid of them. If the problem persists consider armored cable.

E.5 REPLACING THE CHARGE REGULATOR

(a) Switch the refrigerator OFF. If the charge regulator has an ON/OFF switch the charge regulator OFF too.

(b) Cover the solar array with a thick cloth or a sheet. Make sure that the array is completely covered and be careful not to scratch its surface.



COVER THE SOLAR ARRAY BEFORE REPLACING THE REGULATOR

(c) If you cannot cover the solar array, replace the voltage regulator early in the morning or in the evening when the Sun is low in the sky.

(d) LABEL ALL WIRES what you are about to disconnect so that you can reconnect them to the correct points.

(e) Disconnect all the wires from the charge regulator. The wires should be disconnected in the following order:

1.Load positive

2.Load negative

3.Solar array positive

4.Solar array negative

5.Battery positive

6.Battery negative

(f) Remove the old charge regulator from its mounting and replace it with the new one. Make sure that it is the same type of regulator as the old one.

(g) Reconnect all of the wires to the new charge regulator in the following order:

1.Battery negative

2. Battery positive

3.Solar array positive

4.Solar array negative

5.Load negative

6. Load positive

(h) Reconnect the wires from the new charge regulator to the battery terminals.

(I) Uncover the solar array

(j) Switch the refrigerator back ON again.

E.6 REPLACING THE COMPRESSOR CONTROLLER

The compressor controller is fitted to the electrical circuit to reduce the possibility of damage to the compressor motor. If it is faulty, it should be replaced as follows:

(a) Switch the refrigerator OFF.

(b) Disconnect the wires from the battery terminals.

(c) Label all the wires you are about to disconnect.

(d) Disconnect the wires from the faculty compressor controller in the following order:

1. To charge regulator

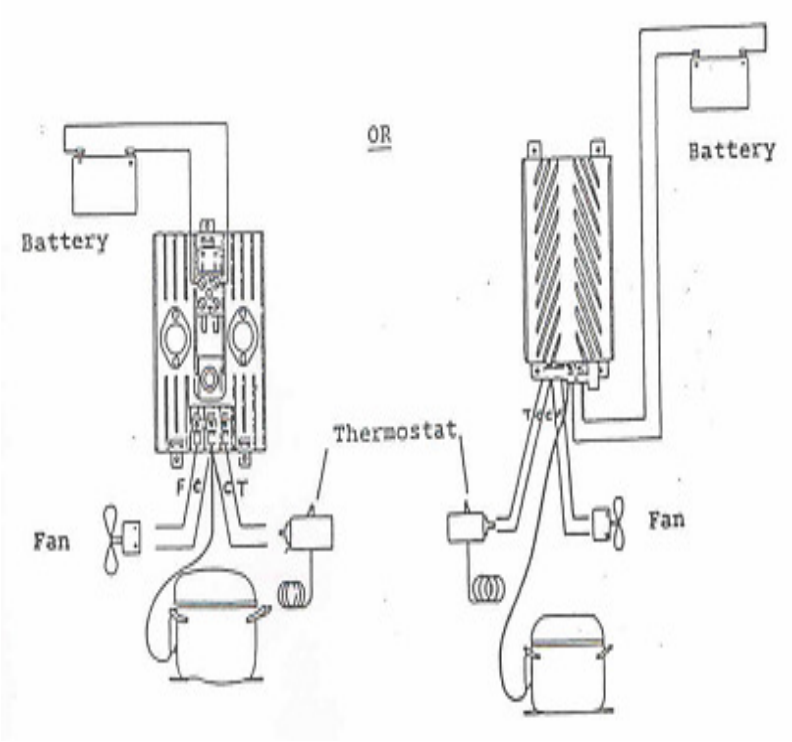
2. To compressor

3. To fan

4. To thermostat

(e) Unscrew the faculty compressor controller from its mountings.

(f) Screw a replacement compressor controller to the mounting. If the compressor is made by DANFOSS, it must be installed vertically with the connection terminals downwards as shown below.



(g) Reconnect all wiring to the compressor controller (ensuring correct polarity) in the reverse order they were disconnected.

(h) Reconnect the wires to the battery terminals.

(I) Switch the refrigerator ON again.

E.7 REPLACING THE CONDENSER FAN (If fitted)

The refrigerator may have a small fan that blow airs onto the condenser tubing too help keep it cool. If there is condenser fan and it is broken, replace it according to the following instructions:

(a) Switch the refrigerator OFF

(b) Disconnect the battery (or batteries)

(c) Mark which wire is connected to the positive terminal and which wire is connected to the negative terminal. Disconnect the wires from the fan terminals.

(d) Unscrew the broken fan from its mounting.

(e) Screw the new fan into place. The new fan must have the same voltage and power ratings as the old one.

(f) Reconnect the wires to the fan terminals making sure that the positive wire is connected to the positive terminal and the negative wire is connected to the negative terminal.

(g) Reconnect the battery

(h) Switch the refrigerator back ON.

E.8 REPLACING A BATTERY

(a) Switch the refrigerator OFF.

(b) Mark which wire goes to the positive terminal and which wire goes to the negative terminal

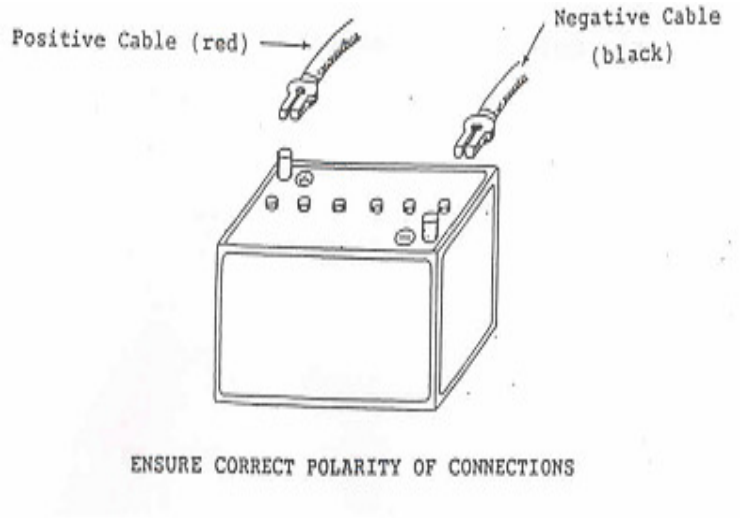
(c) Disconnect the wires of the faulty battery at the battery terminals.

(d) Remove the faulty battery and replace it with a new one. The battery must be of the same type as the old one.

(e) Reconnect the wires to the terminals of the new battery. Make sure that the positive wire is connected to the positive terminal and that the negative wire is connected to the negative battery terminal. If battery terminals of the wire connections are dirty or greasy, clean them with a wire brush or steel wool before connecting them.

(f) If more than one battery is used in the solar refrigerator ensures the connections are correct as indicator below.

(g) Switch the refrigerator back ON again



ENSURE CORRECT POLARITY OF CONNECTIONS

PART 4: RECORD KEPING

1. INTRODUCTION

Record keeping is a very important activity because:

- It provided the repair technician with important information needed for repair work;

- It provides cold chain management with statistics which assist in project evaluation and future project planning;

- It permits better care of vaccines and reduces waste;

- It increases the effectiveness of the immunization program.

Records are kept by the user of the refrigerator system and by the repair technician. It is responsibility of the repair technician to make sure that the user fills in the DAILY RECORD SHEETS correctly and EVERY day.

The DAILY RECORD SHEET that is shown on the next page is completed the twice a day. By the person responsible for using the refrigerator.

A MAINTENANCE RECORD SHEET is completed by the repair technician each time he visits a refrigerator installation and performs checks or does repairs This MAINTENANCE RECORD SHEET. Is kept by the repair technician. It provides a record of repair tasks.

Each time a technician visits a site to perform repairs then he should take with him to the site:

(a) Completed MAINTENANCE RECORD SHEETS for that site, this will help him to see if there has been any change in the performance of any parts of the system and to find out if there is a history of a fault which will assist in diagnosing any new problems.

(b) New MAINTENANCE RECORD SHEETS.

A sample of a MAINTENANCE RECORD SHEET is provided on page 92 and 93.

DAILY RECORD SHEET

Week from to

	TIME	TEMPERATURE IN REFRIGERATOR COMPARTMENT	ABMIENT TEMPERATURE	QUANTITIES LOADED		INDICATION ON	SIGNATURE
				ICE PACKS	VACCINES		
MORNING MONDAY AFTERNOON							
MORNING TUESDAY AFTERNOON							
MORNING WEDNESDAY AFTERNOON							
MORNING THURSDAY AFTERNOON							
MORNING FRIDAY AFTERNOON							
MORNING SATURDAY AFTERNOON							
MORNING SUNDAY AFTERNOON							

MAINTENANCE RECORD SHEET SIDE 1

NAME OF SITE:

MAKE AND MODEL OF REFRIGERATOR:

QUANTITY AND TYPE OF BATTERIES:

QUANTITY AND TYPE OF PV MODULES:

POSSIBLE FAULT	RESULT OF FAULT FINDING CHECK

MAINTENANCE RECORD SHEET SIDE 2

DESCRIPTION OF REPAIR MODE

PARTS USED		
NAME OF PART	QUANTITY	PART NUMBER

CHECKED PERFORMED AFTER THE REPAIR	
NAME OF PART CHECKED	RESULT OF CHECK

DATE OF REPAIR:
NAME OF REPAIR TECHNICIAN:
SIGNATURE OF REPAIR TECHNICIAN
SIGNATURE OF RESPONSIBLE PERSON AT SITE:

2. Completing the maintenance record sheet

The procedure to fill in a MAINTENANCE RECORD SHEET is very easy. The steps are as follows
At the top of the first page:

1. Write the name of the site in the space provided.

2. Write the make and model of refrigerator in the space provided. If you do not know you can find this information in Table 2-SITE DATA SHEET, which is in the USER HANDBOOK. This handbook was provided with the refrigerator .Ask the user for this HANDBOOK.

3,Write quantity and type of batteries in the space provided. You can also find this information in Table 2- SITE DATA SHEET of the USER HANDBOOK.
In the table on the front page:

4.Write the name of the possible fault you are checking in the first space of the left-hand column. This should be the first item shown on the list of possible faults shown in CHART No.1, CHART No.2 or CHART No.3 in (see page 62 to 65)

5. When you have followed the procedure for the first faultfinding and repair task description write the result of your work in the space provided alongside the possible fault.

6.Proceed to the next fault in the chart that corresponds to your symptom and enter the name of the possible fault in the second space on the left hand side of the table.

7. Follow the faultfinding procedure, which corresponds to this fault and enter the result alongside the possible fault.

8. Continue in order through each step on the faultfinding chart until you diagnose the fault. Write down the results of each step before proceeding to the next step.

9. When you reach the step where the fault id diagnosed proceed to the second side of the MAINTENANCE RECORD SHEET.

10. In the space provided under ACTION, describe the repair and give a complete lists of the parts used. including part numbers if possible.

11. Following the repair, check that the component that you have replaced is operating correctly by repeating the “How to Confirm a Fault” for the step where the repair was performed. When this procedure is followed, no fault should now be evident .The results of the checks performed should be entered in the last block of the MAINTENANCE RECORD SHEET.

12.Enter date of repair in the space provided at the bottom of the second side of the MAINTENANCE RECORD SHEET.

13.Write your name clearly underneath the date.

14. Sign the MAINTENANCE RECORD SHEET to verify that the work described on the sheet has been performed.

15. Ask the person at the site who is responsible for the refrigerator to sign the MAINTENANCE RECORD SHEET.

PART 5 USER TRAINING

The installation technician initially does user training when the refrigeration system is installed. The installation technician explains the activities described in the USER HANDBOOK FOR PHOTOVOLTAIC REFRIGERATOR.

As the repair technician you are responsible for continuing the training of the user of the photovoltaic refrigerator system. This training commonly called-on –the job training.

The responsibilities of the repair technician in providing on-the-job-training to the user may be divided into the following 4 parts:

A: ACTION ON HANDOVER

The user should fully understand all the actions on handover that are described in detail in PART 1-ACTIONS ON HANDOVER OF THE USER HANDBOOK FOR PFOTOVOLTAIC REFRIGERATOR.

Actions on handover include:

(a) Identifying to the user the basic parts of the solar refrigerator power supply and the basic parts of the refrigerator cabinet.

(b) Completing Tables 1 to 5 in the User Handbook.

If the person responsible for the photovoltaic refrigerator has recently changed you will need to repeat the training on identifying the basic parts of the solar refrigerator when you visit the site.

B HOW TO OPERATE THE SYSTEM

The user should fully understand how to operate system. This is described in detail in PART 2-HOW TO OPERATE YOUR SYSTEM OF THE USER HANDBOOK FOR PHOTOVOLTAIC REFRIGERATOR. Check that the user understands.

1. How to switch the refrigerator ON.

2. Opening and closing of the refrigerator cabinet.

3. Locking the refrigerator cabinet.

4. When to switch the refrigerator

5. Correct storage temperature and conditions for vaccines.

6. Loading the refrigerator

7. Filling in the DAILY RECORD SHEET.

C: USER MAINTENANCE

The user should fully understands how to do simple maintenance, which is described in detail in PART 3-USER MAINTENANCE of the USER HANDBOOK FOR PHOTOVOLTAIC REFRIGERATOR.

Part3 of the user manual is extremely important. These are the tasks, which the user must do on a regular basis if the refrigerator is to operate correctly. These tasks are grouped into daily, weekly, monthly and six monthly tasks.

As the repair technician you must check that these tasks have been performed. In doing these checks, you should always be accompanied by the user who should assist you in carrying out these tasks. By doing this you can make sure that the user knows how to do each one of them correctly.

This is the most effective type of on-the-job training for the user.

The tasks you should check the user can do are as follows:

Group 1(tasks normally done daily by the users)

1. Fill in the DAILY RECORD SHEET.

2. Check the indicator lights and any other meters.

3. Check that there is free air circulation all around and underneath the refrigerator cabinet.

4.Check that the refrigerator cabinet is not overloaded and that only vaccines and medical supplies are kept in the refrigerator.

Group 2(tasks normally done weekly by the user)

5.Check the amount of ice forming around the freezer compartment. Defrost if necessary.

6. Clean the photovoltaic array.

7.Check for shadowing of the photovoltaic array .Cut back trees or bushes or remove any obstacles.

Group 3 (tasks normally done monthly by the user)

8. Clean the parts of the refrigerator (including the condenser)

Group 4. (Tasks normally done every six months by the user)
.

9. Check the level of the acid in every battery cell (except sealed batteries). Top up with distilled water if necessary.

10. Check that all parts of the system are firmly and safely mounted, and that nothing is visibly damaged. Repair if possible.

11. Check the lid/door seal. Replace if necessary.

D: WHAT TO DO IF A FAULT OCCURS

The user should know what to do if a fault occurs. This is described in detail in “Part 4- what to do if a Fault occurs” of the USER HANDBOOK FOR PHOTOVOLTAIC POWERED REFRIGERATOR.

Part 4 defines a procedure which the user should follow if a fault occurs, it is important that this procedure be fully understood. As the repair technician you should talk to and work with the user to make sure that the user can correctly identify the symptoms of a fault.

Symptoms divide into three basic areas:

1. The refrigerator is too warm (above 8^0C) and the compressor is not running.

2. The refrigerator is too warm (above 8^0C) and the compressor is running.

3. The refrigerator is too cold.

After you sure the user can identify the symptoms of a fault check that he of she knows which checks and actions correspond with the symptoms of the fault. (These are described as page 23 of the USER HANDBOOK)

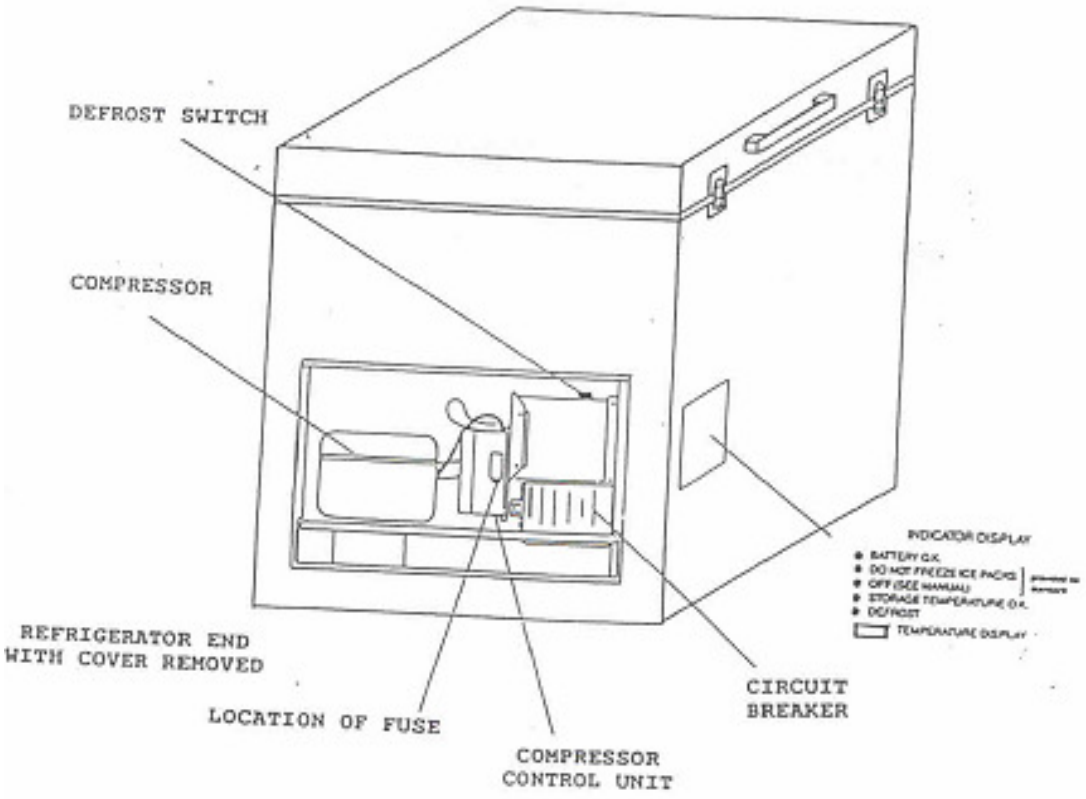
GLOSSARY OF TECHNICAL TERMS

BATTERIES	Store the electricity to supply the SOLAR PHOTOVOLTAIC at night and in cloudy weather when there is no sunshine.
CHARGE REGULATOR	An electronic unit that regulates the amount of electricity being put into the BATTERIES. It prevents over charging and damage to the BATTERIES.
COMPRESSION	Pumps the REFRIGERANTS around the COOLING CIRCUIT. There is an electric motor inside the COMPRESSOR, which makes a humming noise when it is running .The COMPRESSOR will get warm when it is running. This is normal.
CONDENSER	The coil of metal tubing at the back or underneath of the REFRIGERATOR. It transfers the heat removed from the refrigerator to the outside air.
COOLING CIRCUIT	The piping and components in which the REFRIGERANT travels. It includes the EVAPORATOR, CONDENSER and COMPRESSOR.
COMPRESSOR CONTROLLER	The electronic unit that converts the electricity stored in the BATTERIES to the correct requirements of the COMPRESSOR motor.
DOOR/LID SEALING GASKET	The strip of rubber or plastic that goes around the inside edge of the Lid/door of the REFRIGERATOR. The SEALING GASKET stops cold air from getting out of the REFRIGERATOR and warm air from getting in.

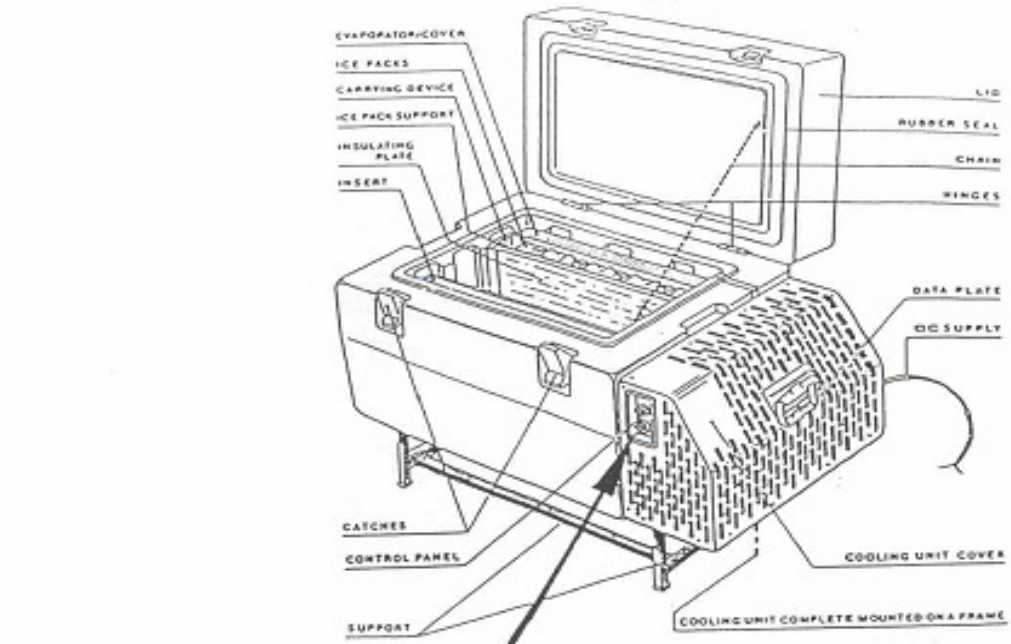
FREEZER COMPARTMENTS	The coldest compartment of the REFRIGERATOR, usually with its own separate door inside the main door. ICEPACKS are frozen inside the FREEZER COMPARTMENT.
FUSE	A small strip of metal (in a holder) that melts when there is too much electricity consumed .A FUSE protects electrical components from damage.
INSTALLATION TECHNICIAN	The person who brings the SOLAR PHOTOVOLTAIC POWERED REFRIGERATOR to the health centre and who puts it together and installs it so that it is ready for use.
MAIN COMPARTMENTS	The largest space in the REFRIGERATOR where the temperature is kept at between 0^0C and $+8^0$C.this is where vaccines and medicines are stored and is often called the VACCINE COMPARTMENT.
PHOTOVOLTAIC	The name for the way in which a SOLAR ARRAY converts sunlight to electricity .PV is a short way of saying PHOTOVOLTAIC.
PV REFRIGERATOR	See SOLAR PHOTOVOLTAIC REFRIGEARTOR.
REFRIGERANT	The fluid that is pumped through the COOLING CIRCUIT by the COMPRESSOR .The REFRIGERANT carries heat out of the REFRIGERATIOR.
REFRIGERATOR	An insulated cabinet that can keep vaccine and medicine cold. The REFRIGERATOR may be front loading and have a door, or it may be top loading and have a lid. It may also have a FREEZER COMPARTMENT to freeze ICEPACKS.

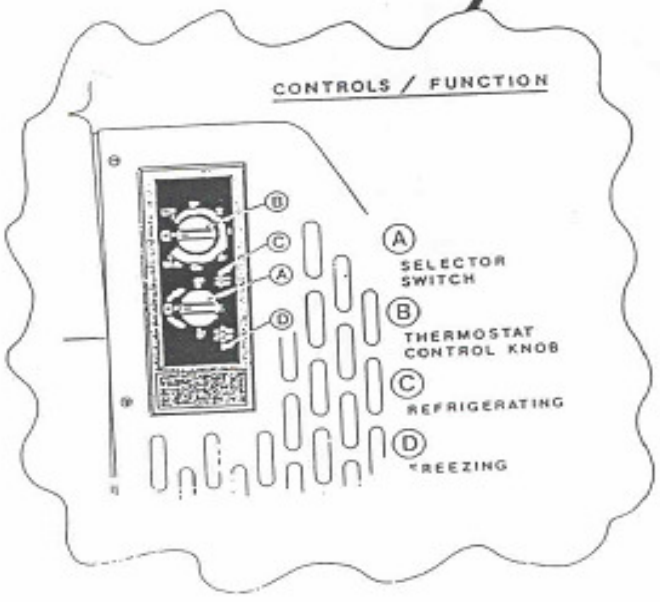
SERVICE AND REPAIR TECHNICIAN	The person who visits the health post to carry out regular preventative maintenance on the SOLAR PHOTOVOLTAIC REFRIGERATOR and any repairs the are necessary
SOLAR ARRAY	Produces electricity when sunlight falls on it. Often referred to as the PV ARRAY.
SOLAR PHOTOVOLTAIC REFRIGERATOR	A REFRIGERATOR supplied with electricity from a SOLAR ARRAY. Also known as SOLAR REFRIGERATOR or PV REFRIGERATOR.
THERMOSTAT	The device that controls the temperature inside the MAIN COMPARTMENT of the REFRIGERATOR
TILT ANGLE	The angle that the SOLAR ARRAY makes with the horizontal ground.
VACCINE COMPARTMENT	The MAIN COMPARTMENT of the REFRIGERATOR where the temperature is kept at between 0^0C to 8^0C for the storage of vaccine.
VENTILATION GRILLE	An opening in the side of the SOLAR POWERED REFRIGERATOR tat allows air to circulate around the CONDENSER and COMPRESSOR.

ANNEX 1
COMPONENT LAYOUTS OF SOME COMMONLY USED SOLAR REFRIGERATOR

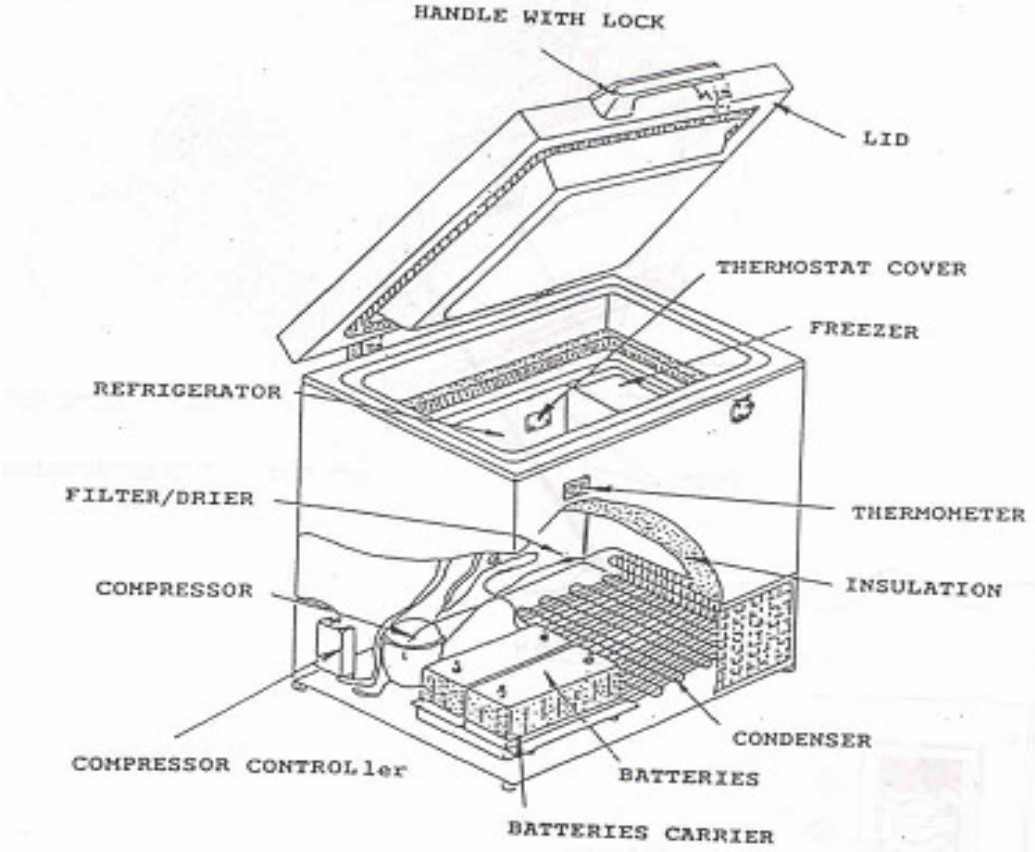


BP SOLAR VR50

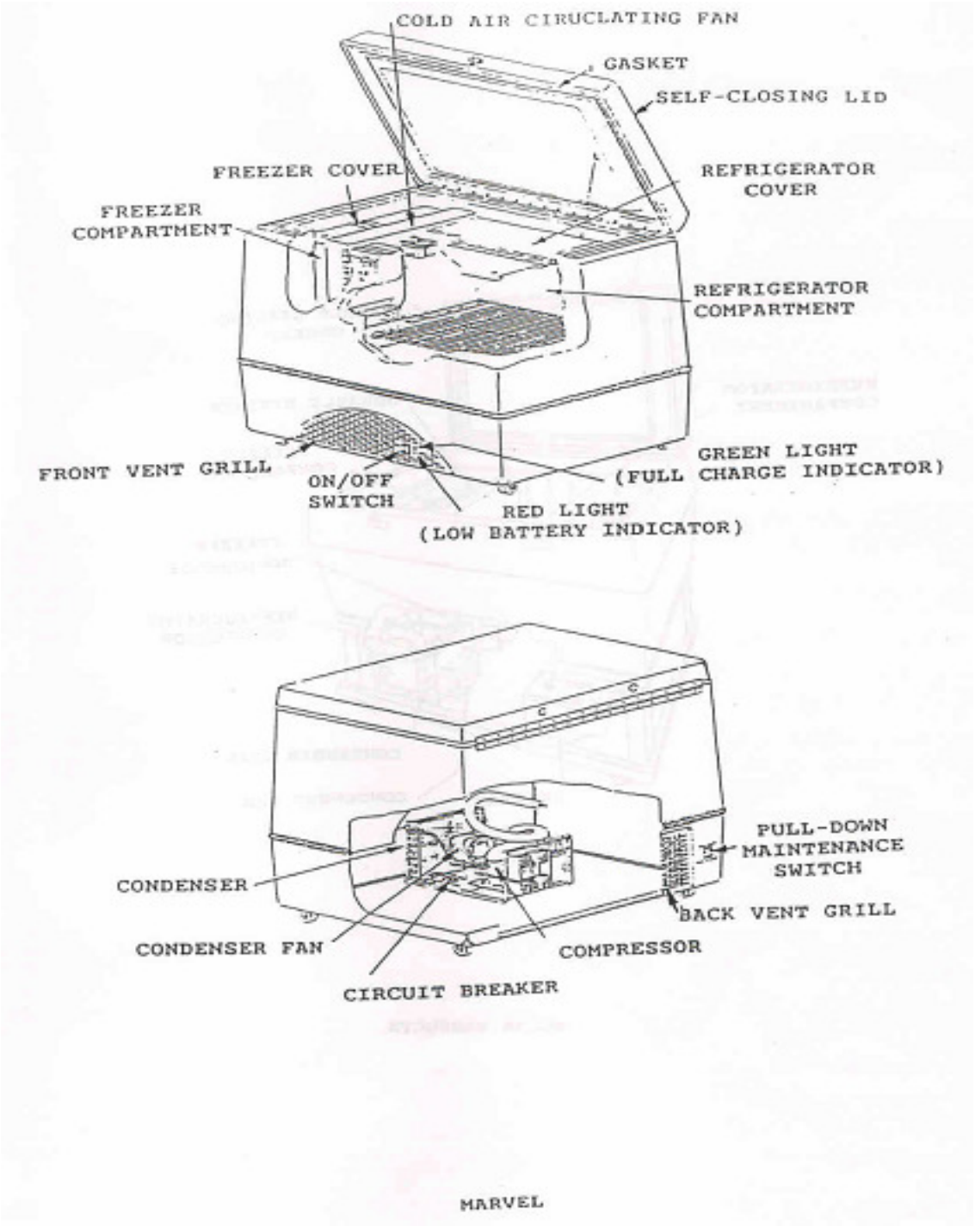


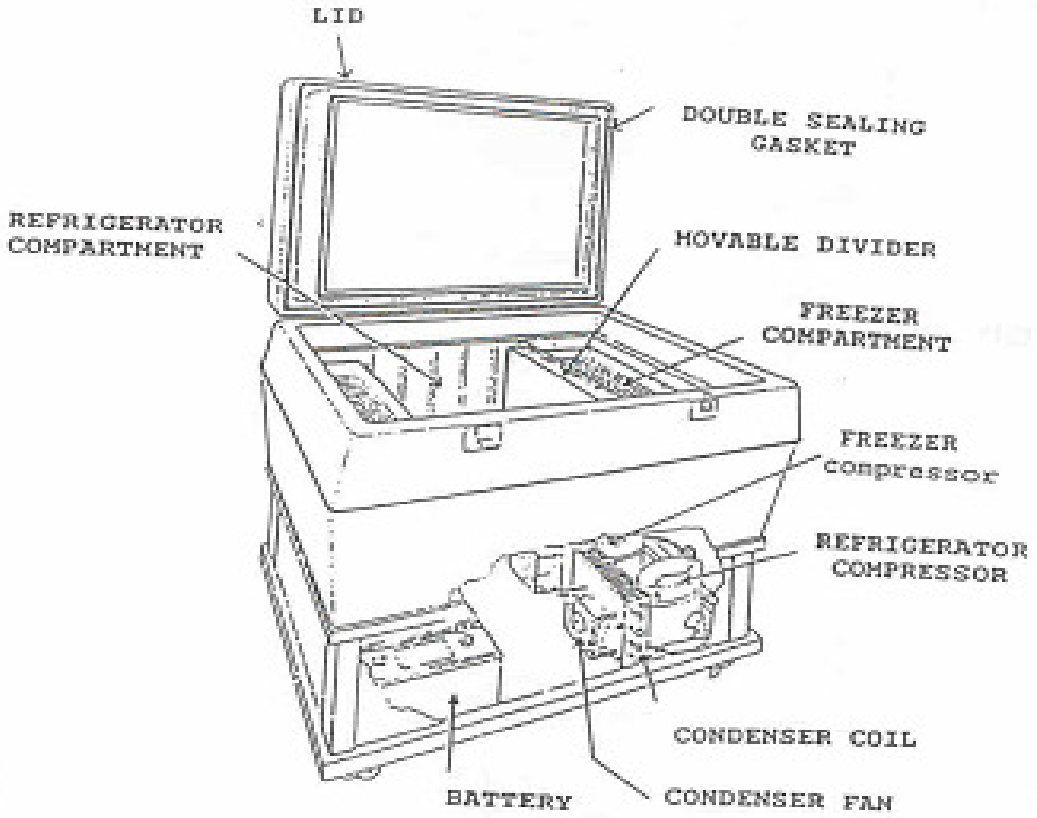


ELECTROLUX RCW42


HANDLE WITH LOCK
LID
THERMOSTAT COVER
FREEZER
REFRIGERATOR
FILTER/DRIER
THERMOMETER
COMPRESSOR
INSULATION
CONDENSER
COMPRESSOR CONTROLler
BATTERIES
BATTERIES CARRIER

FNMA 75


COLD AIR CIRUCLATING FAN
GASKET
SELF-CLOSING LID
FREEZER COVER
REFRIGERATOR COVER
FREEZER COMPARTMENT
REFRIGERATOR COMPARTMENT
FRONT VENT GRILL
ON/OFF SWITCH
GREEN LIGHT (FULL CHARGE INDICATOR)
RED LIGHT (LOW BATTERY INDICATOR)
PULL-DOWN MAINTENANCE SWITCH
CONDENSER
BACK VENT GRILL
CONDENSER FAN
COMPRESSOR
CIRCUIT BREAKER
MARVEL



POLAR PRODUCTS

ANNEX II

ADDITIONAL EPI TOOL KIT NEEDED

FOR PHOTOVOLTAIC REFRIGERATOR

REPAIR

ADDITIONAL TOOLS REQUIRED TO THE STANDARD UNIPAC/EPI TOOL KIT

-Millimeter (digital)
- ●10 Amp
- ● 10 mV accuracy
- ● Ohm

- 2 shunts
- ● 0-200 mV at 0-20 Amps
- 1 hydrometer, break proof
- 1 compass
- 1 pair of plastic gloves
- 1 spirit level
- 1 latitude template (to manufacture on site)
- 1 mercury in glass thermometer-range 10-60 ^{0}C
- 1 protective sheath for thermometer
- 1 bimetal thermometer

DULAS limited

SECTION III

SYSTEM HANDBOOK

WORLD HEALTH ORGANISATION

A USER HANDBOOK
FOR
PHOTOVOLTAIC REFRIGERATOR

DULAS LTD.
Dyfi Eco Parc
Machynlleth,
Powys,
WALES's SY20 8AX
U.K.
Tel +44(0) 1654 705000
Fax +44(0) 1654 703000
E-mail: solar@dulas.org.uk
Website: www.dulas.org.uk

A USER HANDBOOK
FOR
PHOTOVOLTAIC POWERED REFRIGERATOR

CONTENTS

SCOPE

The World Health Organization Expanded Programme on Immunization has published this handbook.
It is a handbook for users of stand-alone, photovoltaic powered compression refrigerators operating at 12 V or 24 V DC in medical centers. These refrigerators are used for storing vaccines and medicine and for freezing icepacks. Stand-alone means here that the solar array does not power any other device (e.g. lights) and the refrigerator is powered only from the solar array.
This handbook should not be used for any other types of refrigerator.

1. ACTION ON HANDOVER

You should read this section before the installation technicians have left the health centre. There are some important questions that you must ask them before they go.

Getting to know your solar refrigerator

Your new solar refrigerator is an important part of the cold chain. You can store vaccine and medicine in it safely, and freeze icepacks in the freezer compartment. But for the refrigerator to operate properly, you must be familiar with its parts and understand how to use it.

A solar powered generator is not the same as a refrigerator that burns kerosene or bottled gas. It is similar to a refrigerator that uses mains electricity but has a different power supply-solar energy converted into direct current electricity by solar cells.

Figure 1 shows the basic parts of your solar refrigerator Power supply.
These Parts are: the solar Array, the charge regulator and the batteries. Together they provide the electricity for the refrigerator. The solar array can be roof-mounted, mounted on a pole or located at ground level with a protective fence around it. The batteries and charge regulator can be mounted in the refrigerator cabinet or placed nearby in suitably protected cases.
Figure 2 shows a typical solar refrigerator cabinet and the location of the parts.

Before the installation technicians leave, you should

1. Ask them to provide you with the information listed in Table 1.

2. Fill in table 2 and sign it.

3. Fill in the first entry in Daily Record Sheet like the example shown in table 3.

4. Check that the installation is CORRECT by answering the questions in table 4

5. Check that the refrigerator system is OPERATING CORRECTLY by answering the questions in table 5.

Figure 1. SOLAR ELECTRICITY SUPPLY FOR A PHOTOVOLTAIC REFRIGERATOR

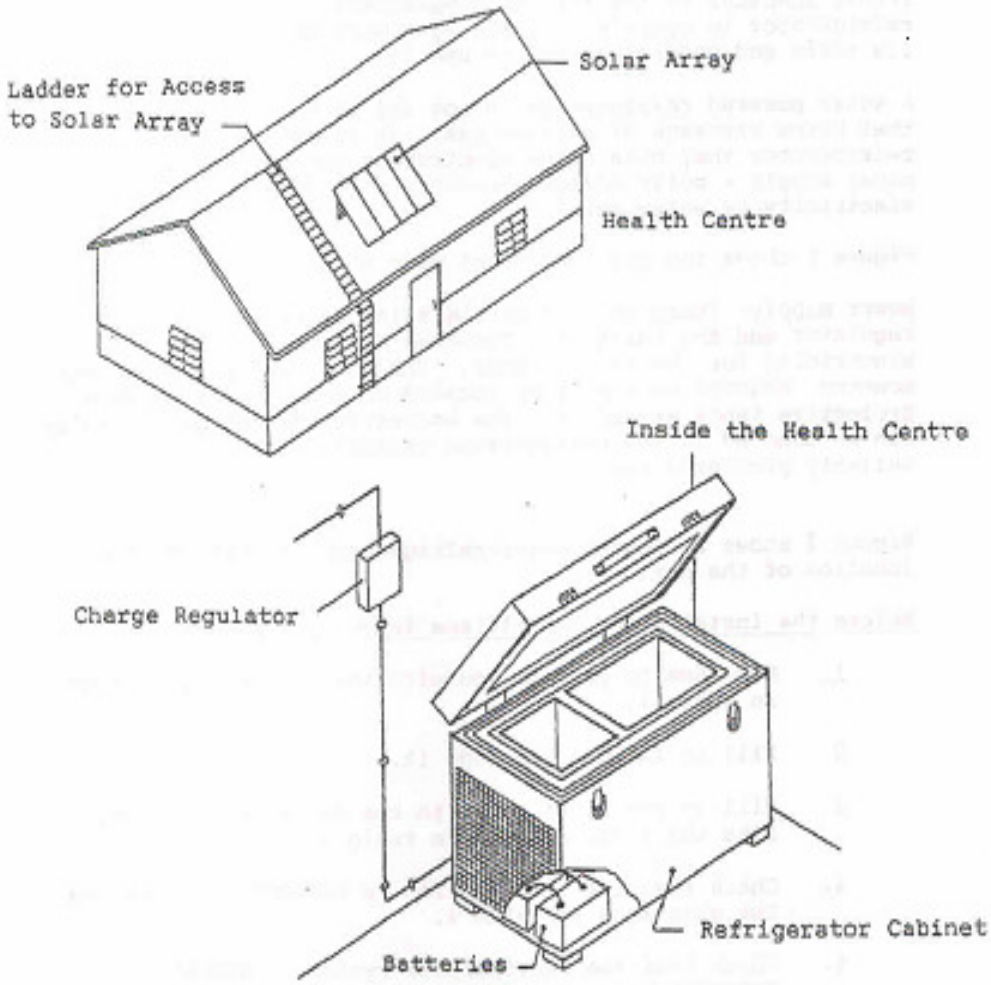
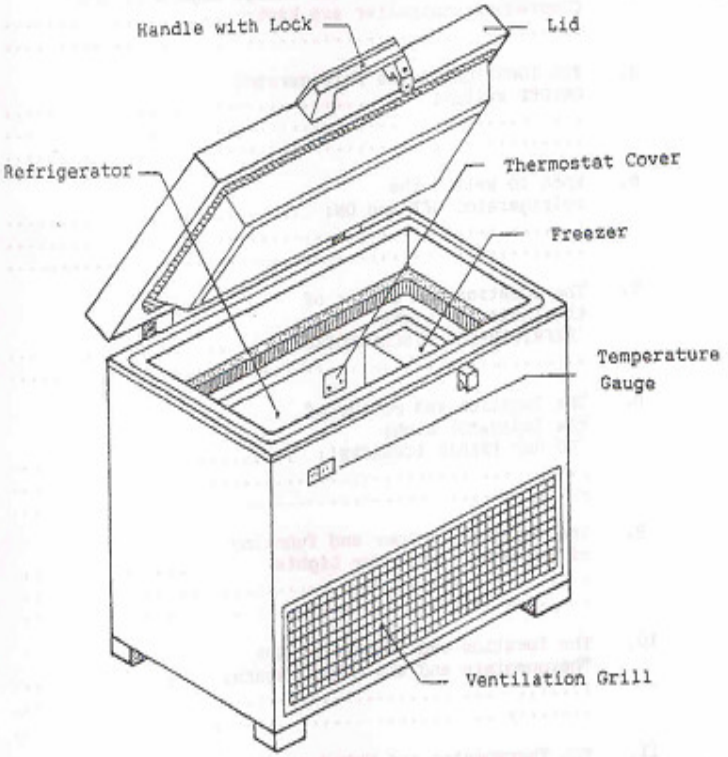


Figure 2. A TYPICAL REFRIGERATOR CABINET



Tables 1 ASK THE INSTALLATION TECHNICIAN TO PROVIDE YOU WITH THE FOLLOWING INFORMATION AND WRITE IT DOWN ON THIS PAGE.

1. Maximum number of icepacks to be
Placed in the freezer in any one day:……..

2. Vaccines capacity of
Refrigerator compartment: ……liters

3 The Model of the Refrigerator……

4. Where spare fuses for the charge Regulator and compressor controller are
Kept……..
…….

5. The location of the Refrigerator ON/OFF switch……
……..
……

6. When to switch the refrigerator OFF and ON…….
…….
7. The location and the color of the indicator light
'REFRIGERATOR DISCONNECTED':……
……..
8. The location and the color of the indicator light
'Do Not FREEZE ICEPACKS':……..
…….
9. The location color and function of any
Other indicator lights:……..
……..
10. The location and purpose of the Thermometers
And any other Meters:……
……..
……

11. The Thermometer and Meter readings
Which indicate normal operation:……
…….

Table 2 SITE DATA SHEET
(TO BE COMPLETED AND SIGNED BY THE TECHNICIAN AND USER)

1. Full Address of Health Centre:…….
……..
……..

2. Name and rank of person
Responsible for centre:…….
……..
…….

3. Names of centers Staff trained
To use and do user level
Maintenance on system……
……..
……..

4. Data solar refrigerator system installed:……..
…….

5. Make and model of refrigerator:…….
Unit installed.

6. Make and model of charge regulator
Installed:……..
…….

7. Quantity and Type of
Batteries installed:…….
…….

8. Quantity and Type of
Photovoltaic Modules installed:……..
…….

9. Array Mounting Arrangement (Tick arrangement used):
   - Roof with means of safe access……..
   - Pole with possibility for cleaning array…….
   - Ground with protective fence…….

10. List of tools, manuals, record sheets and supplies provided for user (tick and indicate quantity id supplied)

- Daily Record Sheets……..
- 10 fuses for each place……
- Distilled water in closed container…….
- Talcum powder……..
- Flat-bladed screwdriver…….
- Phillips screwdriver……
- Soft brush to clean condenser…….
- Sponge to clean Array……..
- Padlocks and keys……
- Petroleum Jelly……
- Battery refill bottle with spout…….
- Thermometer to measure refrigerator compartment……
- USER HANDBOOK FOR PHOTOVOLTAIC REFRIGERATORS ……
- Manufacturers Manual…….

11. Name and Address of solar Refrigerator Technician responsible for Maintenance of system:……..
……
……
……

12. How to contact solar Refrigerator Technician:……..
……
……

VERIFIED AND APPROVED BY:

Person responsible for centre Chief installation technician

Table 3 EXAMPLE OF DAILY RECORD SHEET

DAILY RECORD SHEET
Week from to

	TIME	TEMPERATURE IN REFRIGERATOR COMPARTMENT	ABMIENT TEMPERATURE	QUANTITIES LOADED		INDICATION ON	SIGNATURE
				ICEPACKS	VACCINES		
MORNING MONDAY							
AFTERNOON							
MORNING TUESDAY							
AFTERNOON							
MORNING WEDNESDAY							
AFTERNOON							
MORNING THURSDAY							
AFTERNOON							
MORNING FRIDAY							
AFTERNOON							
MORNING SATURDAY AFTERNOON							
MORNING SUNDAY AFTERNOON							

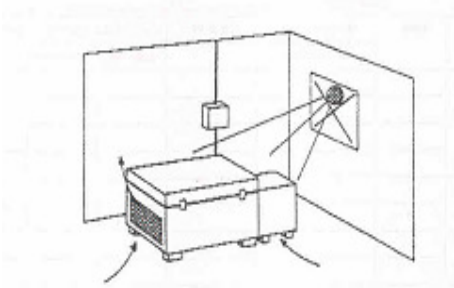
Table 4 IS THE INSTALLATION CORRECT?

The Solar Array:

- Can you reach it easily and safely to clean it?
- Is it protected so that unauthorized persons cannot damage it?
- Are the cables, which are connected to the array firmly attached of, hidden?

The Refrigerator Cabinet:

- Is there good air circulation around all sides and on top of the Refrigerator cabinets especially in front of the ventilation grill?



- Is the refrigerator cabinet placed so that it is NEVER in direct sunlight?
- Is the refrigerator cabinet raised off the floor so that it can readily be cleaned around and will not be damaged by water used to wash the floor?
- Can you reach the doors and locks easily?

The Charge Regulator and Batteries:

- Are the charge regulator and Batteries mounted in protective cases?
- Are the cases attached to the wal, floor or refrigerator cabinet?
- Are all the cables firmly attached of hidden?

IF THE ANSWER TO ALL QUESTIONS IS YES,
THE INSTALLATION IS CORRECT

Table 5 IS THE PHOTOVOLTAIC REFRIGERATOR SYSTEM OPERATING CORRECTLY?

- Does the refrigerator cabinet LID close properly?

- Is the THERMOMETER in the refrigerator cabinet showing temperature of more than 0^0C and less tan 8^0C?

- Are the INDICATOR LIGHT showing that ICE PACKS MAY BE FROZEN?

- Does the COMPRESSOR start and stop periodically?

IF THE ANSWER TO ALL QUESTIONS IS YES
THE INSTALLATION IS CORRECT

2 HOW TO OPERATE YOUR SYSTEM

2.1 General Remarks

(a) The refrigerator must always be turned on during normal use.

(b) Only open the refrigerator cabinet when it is necessary. Make sure that you close it quickly and securely.

(c) Always lock the refrigerator cabinet immediately after use.

(d) Only turn the refrigerator OFF when:
0 you need to defrost the evaporator
0 you need to change a fuse

(e) Keep all Vaccines in the refrigerator and in accordance with EPI recommendations. The correct temperature for vaccine storage is more than 0^0C and less than 8^0C.NEVER PUT DPT OR TETANUS TOXOID IN THE FREEZER COMPARTMENT.

2.2 Loading the Refrigerator

(a) DO NOT LOAD icepacks if the “DO NOT FREEZE ICEPACK” indicator light is on.

(b) LOAD the freezer compartment with ICE PACKS IN THE MORNING ONLY.

(c) Do not put more than the recommended amount of icepacks in the freezer compartment in any one-day

(d) Do not put more than the recommended amount of vaccine in the refrigerator compartment

(e) You should leave about 5 cm (2 inches) between the cartons of vaccines. This allows the cold air to move around the refrigerator compartment.

(f) Always keep the same type of vaccine together and store your vaccines neatly.

(g) You must use all the old vaccines before the new ones. So you should put new vaccines underneath or behind old vaccines. Before use, make sue that vaccine has not expired.

(h) DO NOT KEEP FOOD OR DRINK IN THE REFRIGERATOR OR ANY NON-, EDICAL ITEM. The solar array can only produce a certain amount of electricity each day. If food or drink is placed in the refrigerator there will not be enough electricity to cool the vaccine.

2.3 Filling in the DAILY RECORD SHEET

(a) Look at the TIME and Write this down in the correct row in your DAILY RECORD SHEET. The record sheet shows the day of week and whether the entry you are making is a morning or afternoon recording. Choose the correct row to make your entry.

(b) Check the TEMPERATURE INSIDE THR REFRIGERATOR COMPARTMENT and record it on your DAILY RECORD SHEET.
If the temperature is NOT between 0^0C and 8^0C, go to section 4 of this handbook" WHAT TO DO IF A FAULT OCCURS" for the action you ust take.

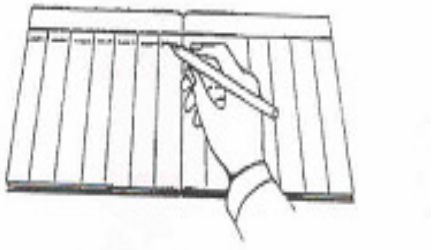
(c) Check the ROOM TEMPERATURE and record it on your DAILY RECORD SHEET.

(d) Count the NUMBER OF ICE PACKS loaded into the freezer Compartment each morning, and record it on your DAILY RECORD SHEET.

(e) Count or estimate the QUANTITY OF VACCINES AND MEDICINE loaded into the refrigerator compartment since the last time the DAILY RECORD SHEET was filled in and enter this quantity on the sheet.

(f) Look at the INDICATOR LIGHTS and enter in your DAILY RECORD SHEET, which COLOURS are illuminated.

(g) Check that you have CORRECTLY filled in the DAILY RECORD SHEET and SIGN IT.



FILL IN RECORD SHEET TWICE A DAY

3. USER MAINTENANCE

Daily tasks

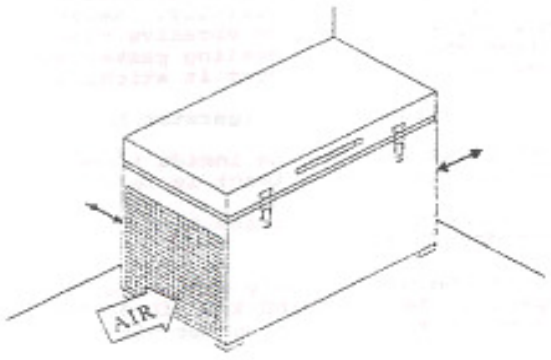
(a) Fill in the DAILY RECORD SHEET each morning and afternoon.
The refrigerator compartment temperature must be more than 0^0C and less than 8^0C.If the temperature is not correct, then to go section 4 of this handbook “WHAT TO DO IF A FAULT OCCURS” for the action you must take.

(b) Check the INDICATOR LIGHTS and any other METERS. If any of them indicates that the refrigerator system is not operating normally then:

- MOVE ALL VACCINE TO ANOTHER PLACE if FRIDGE DISCONNECTED indicator light is LIT.

- REMOVE UNFROZEN ICE PACKS from the freezer compartment if the ‘DO NOT FREEZE ICE PACKS” indicator light is LIT.

(c) Make sure that the refrigerator ventilation grill (if fitted) is not blocked or obstructed and that there is free air circulation all around and underneath the refrigerator cabinet.



FREE AIR CIRCULATION

3.2 Weekly tasks

(a) Check the amount of ice forming around the freezer compartment .it is normal for a little ice to from in the freezer, but if the ice is thicker than 5mm(1/4 inch) then move the vaccine to another refrigerator or store it in a cold box with ice packs. The refrigerator must be switched off, and the refrigerator cabinet defrosted.
The proper steps for DEFROSTING THE REFRIGERATOR CABINET are as follows:

(I) Move the vaccine to another refrigerator or store it in a cold box
With frozen icepacks.

(ii) Switch the refrigerator OFF

(iii) Open the lid/door of the refrigerator and freezer compartment, and
Remove separator if possible.

(iv) As soon as it is possible to remove ice with your fingers, do so. Do not remove ice with knives or any other sharp objects.

(v) Wipe the freezer compartment dry after all the ice has melted.

(vi) Clean the refrigerator inside with soap and water, and then dry it carefully. NEVER use scouring powder, steel wool or abrasive cleaners. Remember to clean the lid/door-sealing gasket and put some talcum powder on it to prevent it sticking to the doorframe.

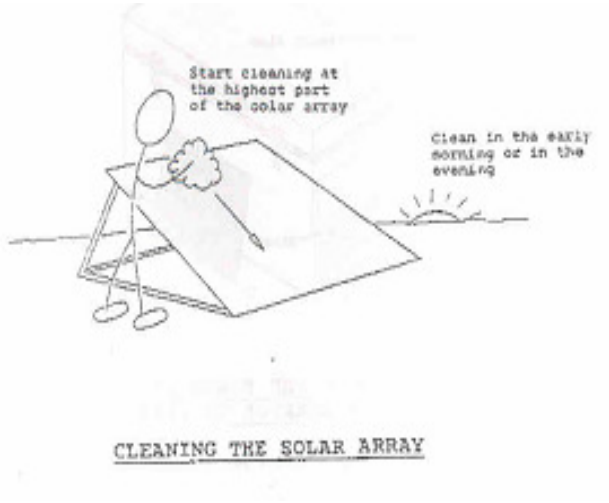
(vii) Switch the refrigerator back ON.

(viii) Wait until the inside temperature in the refrigerator compartment is less than 8^0C.

(ix) Return the vaccine to the refrigerator and close the door/lid.

If defrosting is necessary every week, the lid is probably not sealing properly. See CHECKING THE LID OR DOOR SEALING GASKET described later in this section under Six-Monthly Tasks.

(b) Clean the solar array. Dust and Dirt on the solar array reduces its capacity to produce electricity. It should always be kept clean.
The proper steps for CLEANING THE SOLAR ARRAY are as follows:



CLEANING THE SOLAR ARRAY

(I) Remember- always cleans in the early morning or evening when the solar array is not in strong sunlight to avoid risk of damage.

(ii) Wash the Array using plenty of clean water and a clean soft cloth or sponge. Do not scratch the surface of the array.

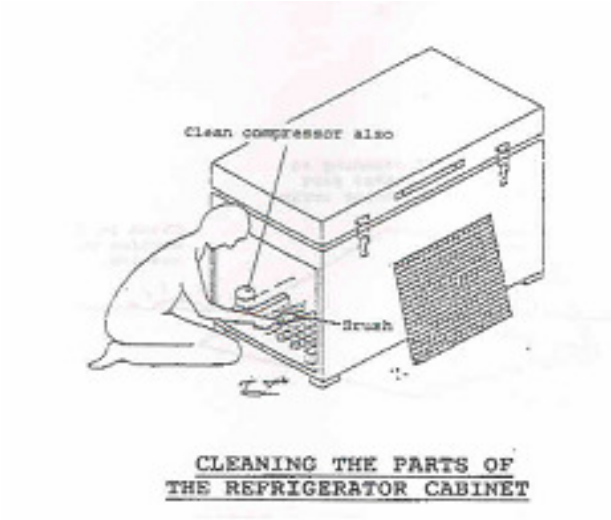
(iii) Wipe the surface of the solar array gently, startingat the highest point and working down to the lowest point. Make sure that all the dust and dirt is removed.

(iv) Do not stand on the solar array, or lean heavily on it, as this may break it.

Access to the solar array should be easy and safe. Ask the service or installation technician to provide a better method of access if you think the present arrangement is unsafe or if you do not feel comfortable about cleaning the array.

3.3Monthly tasks

(a) Clean the parts of the refrigerator cabinet. To Operate correctly and reliably, the refrigerator cabinet and the parts inside it must remain clean. The proper steps for CLEANING THE PARTS OF THE REFRIGERATOR CABINET are as follows:



CLEANING THE PARTS OF THE REFRIGERATOR CABINET

(I) Switch OFF the refrigerator.

(ii) Remove or open the Cover which provided access to the compressor, condenser and fan (if fitted) of the refrigerator cabinet.

(iii) Use the Soft brush provided with your refrigerator to remove any dust and dirt from the condenser and compressor

(iv) If the condenser is fitted with a fan make sure that the fan rotates freely, and brush dirt and dust away from the fan and fan motor.

(v) Switch the refrigerator ON again.

(vi) Wipe cleans the outside of the refrigerator using soap and water.

(b) Check for shadowing of the array Shading of the array, even partly will reduce the amount of electricity produced for the refrigerator. Check that the Solar array is not shaded during hours of sunlight. This should be checked at approximately 8 am, 12 noon and 4 pm .The following action is necessary if you find that any part of array is shaded during normal sunlight hours:

CUT BACK TREES OR BUSHES WHICH SHADE THE ARRAY

(I) Cut back bushes and trees that may have started to shade the solar array between 8 am and 4 pm. Trees and bushes, which only cause shading in early morning. (Before 8 am) or late afternoon (after 4 pm) do not need to be cut. Do not cut down more bushes or trees than necessary and always seek the permission of the person responsible for them by explaining why it is necessary.

(ii) Make sure that nobody has put anything in front of the solar array that may block the sunshine falling on it.

(iii) If new buildings cause shadows to fall on the array, it may be necessary to move the array to an unshaded place. Ask your technician to check and if necessary, move the array.

3.4Six-Monthly tasks

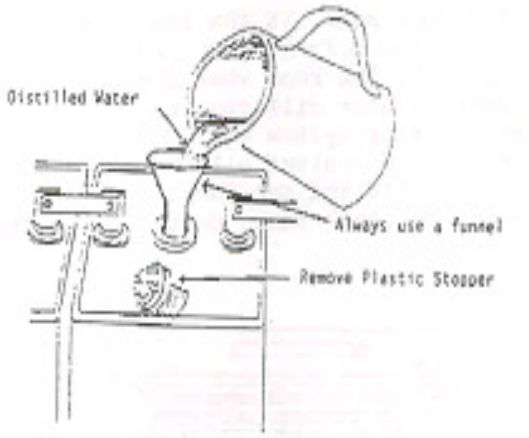
(a) Check level of acid in all types of batteries, which are sealed. If the level of the electrolyte (acid mixture) in any of the cells in the batteries drops sufficiently to expose the plates of the battery, then the battery will be damaged and the refrigerator will not operate properly. Checks are necessary, but following safety regulations MUST be observed.

IGHTS, SPARKS AND HEAT AWAY FROM BATTERIES AS
ASES MAY BE PRESENT

LECTROLYTE) IN BATTERIES IS CORROSIVE. KEEP OFF THE SKIN
Y FRO EYES.AVOID CONTACT WITH CLOTHES.

If the batteries are sealed they will NEVER need topping up.

NEVER ADD ACID



ADDING WATER TO THE BATTERIES

(I) If the batteries are not of the sealed type, then they will have plastic stoppers or a plastic lid on the top. Remove each stopper or each lid one by one and see if the metal plates inside are covered by liquid. There is often a mark on indicator, which shows the correct level.

(ii) ADD DISTILLED WATER if necessary to each cell until it is filled up to the correct level indicated or until the metal plates are well covered. DO NOT fill the battery up until it overflows. Use the plastic bottle with a spout or a clean funnel to put in the water.

(iii) Replace each stopper or lid.

(iv) Do this for all of the compartments in each battery.

It is important that only DISTILLED WATER is used.

(b) Check that:

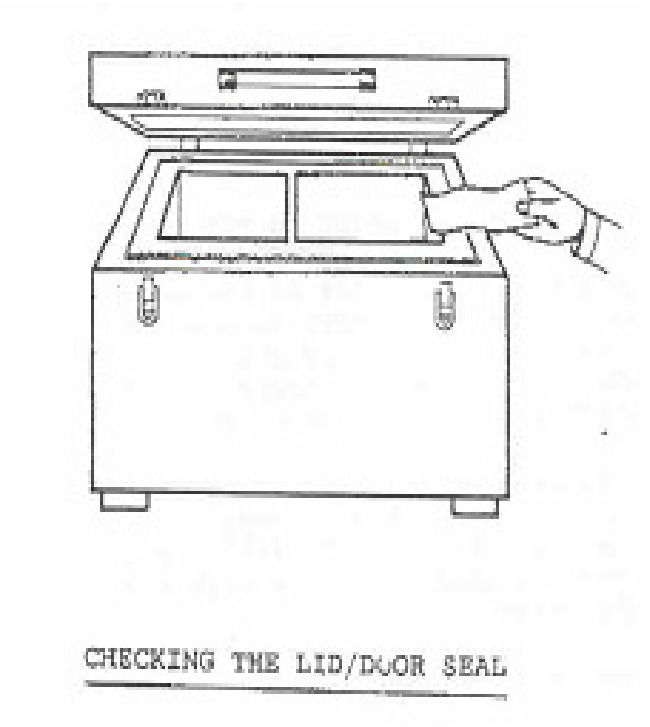
- The array is firmly mounted

- All cables or electrical wiring connecting the different parts of the system together are firmly attached and not damaged.

- The battery and charge regulator cases are firmly attached to the wall of floor if they are not inside the refrigerated cabinet, and finally
- No parts of the refrigerator cabinet are loose or dangerous to the people who use the refrigerator system.

If any of the parts checked above are NOT satisfactory then CONTACT THE MAINTENANCE TECHNICIAN IMMEDIATELY.

(c) Check the lid/door seal. If the seal does not prevent the cold inside the refrigerator and freezer compartments from escaping into the room when the door/lid is closed. Then your refrigerator will require more electricity to run and the refrigerator system will not operate correctly. The SEAL MUST make good contact all the way around the joint between the door /lid and the compartments in order for it to seal properly. To check this does the following:



CHECKING THE LID/DOOR SEAL

(I) Open the refrigerator and place a thin paper strip over the place where the seal of the refrigerator cabinet comes into contact with the lid/door.

(ii) Close the lid/door

(iii) Pull the paper strip .If it moves easily the door/lid needs adjustment or the seal needs replacing.

(iv) Try the paper stir all around the lid/door in this way, paying special attention to the corners.

(v) Check all the ways around the lid/door in this way. Paying particular attention to the corners.

(vi) If the seal is coming loose, glue it back on. If this is not possible, request a replacement seal.

If you are unable to make the seal fit CORRECTLY, all of the way around the joint, CALL THE MAINTENANCE TECHNICIAN.

4. WHAT TO DO IF A FAULT OCCURS.

DO THE FOLLOWING

First, identify the symptoms of the fault by finding out if:

(a) The refrigerator is too warm (above 8^0C) and the compressor is NOT running. You may determine if the compressor is running by:

- Listening for the motor noise from the compressor

  Or

- Touching the compressor to see if it is vibrating

  Or

- Touching the compressor to see if it is warm.

(b) The refrigerator is too warm (above 8^0C) and the compressor is running at times.

(c) The refrigerator is too cold.

Next, do the CHECKS and ACTIONS, which correspond with the symptoms of the fault you have found out above. These CHECKS and ACTIONS are explained in the page of this manual. It is IMPORTANT that:

(a) You be sure your choice of symptom is correct.

(b) You always start with the first step listed on each page and proceed in order through all the steps.

(c) If, after doing ALL the CHECKS and ACTIONS the refrigerator is still not working properly, you start at the beginning and check everything again.

(d) If after checking all the faults twice, the refrigerator is still not working properly, you move the vaccine into another refrigerator or a cold box and call the technician immediately.

(e) You note in the DAILY RECORD SHEET the CHECKS you made and the ACTIONS taken. This will help the solar fridge technician to identify the fault with your refrigerator.

4.1 The refrigerator is too warm (above 8^0C) and the compressor is NOT RUNNING.

(a) Check that it is switched ON. If not, then switch it ON.

(b) DO ALL the user maintenance tasks defined in Section 3 of this manual.

(c) Check that the thermostat setting has NOT been changed if the model fitted to your refrigerator can be adjusted. Reset it at the initial position.

(d) Check that the fuse has not blown. If it has, replace it. If the fuse blows for a second time call the solar fridge technician.

4.2The refrigerator is too warm (above 8^0C) and the compressor is running at times.

(a) DO ALL the user maintenance tasks defined in Section 3 of this manual.

(b) Check that the thermostat setting has NOT been changed if the model fitted to your refrigerator can be adjusted. Reset it at the initial position.

(c) If the refrigerator compartment temperature is still more than 8^0C,call the solar refrigeration technician.

4.3 The refrigerator is too cold.

Remember: NEVER FREEZE VACCINE. If the refrigerator is too cold and the vaccine is in danger of being frozen remove the vaccine to another refrigerator or cold box until the refrigerator temperature is again above 0^0C.

(a) Some refrigerators have a removable separator between the freezer compartment and the refrigerator compartment. If this has been removed, incorrectly positioned, or is partly broken, replace or repair it.

(b) Check that the thermostat setting has NOT been changed if the setting of thermostat fitted to your refrigerator can be adjusted.

Reset it at the initial position. It will take some time for the temperature to rise, but if after 1 hour the temperature has not risen noticeably, transfer the vaccine to another refrigerator or cold box and call the solar refrigerator technician.